Vol. XII.—No. 54.] [JUNE, 1898.

THE

MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

Mineralogical Society.

INSTITUTED 3rd FEBRUARY, 1876.

EDITED BY H. A. MIERS, M.A., F.R.S.,

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THE MINERALOGICAL SOCIETY

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, February 1st, 1898.

N. S. Maskelyne, Esq., F.R.S., President, in the Chair.

The death of Professor Heddle, Past President, was announced.

Professor Church was elected, by co-optation, to the office of Vice-President vacated through the death of the Rev. Prof. S. Haughton.

Mr. E. G. J. Hartley was elected an Ordinary Member of the Society.

The resignation of Dr. Robert Oxland, Original Member of the Society, was reported.

GENERAL MEETING.

Held in the Apartments of the Geological Society, February 1st, 1898.

N. S. Maskelyne, Esq., F.R.S., President, in the Chair.

Eighteen Members were present.

The following papers were read:—

1. Canfieldite from Bolivia: Specific identity of so-called "Crystallised Brogniardite" and Canfieldite: by Mr. G. T. Prior and Mr. L. J. Spencer.

2. On Atacamite from Sierra Gorda, Atacama: by Mr. G. F. H. Smith.

Mr. Bowman showed specimens of stibnite in which the differences of conductivity for heat in different directions were proved by the volatilisation of a thin layer of ammonium chloride from the neighbourhood of a heated point, and specimens of gypsum from which the water had been driven off in the vicinity of a heated point.

Mr. Prior showed some balls of oolitic limestone from Turk's Island, Bahamas, and Mr. Hutchinson an enlarged photograph of the late Professor Miller, of Cambridge.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, April 5th, 1898.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

The resignation of Mr. John Gill was accepted.

The audited Balance Sheet for the year ending Dec. 31st, 1897, was

submitted and approved: the Secretary was instructed to insert it in the Minutes as usual, and to issue a printed copy with the next number of the Journal.

GENERAL MEETING.

Held in the Apartments of the Geological Society, April 5th, 1898.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

Eleven Members were present.

The following papers were read:—

1. Sphærostilbite: by Mr. G. T. Prior.

2. On the occurrence of Monazite, and niobates and tantalates of the rare earths, in Swaziland: by Mr. G. T. Prior.

3. On a cubic modification of silver iodide from Broken Hill, New South Wales: by Mr. L. J. Spencer.

4. On peculiar quartz-pseudomorphs found at the Owera Mine, Opitonui, New Zealand: by Prof. G. H. F. Ulrich (communicated by Professor Judd).

5. Crystallographic notes on Laurionite and Phosgenite: by Mr. Herbert Smith.

6. On Senaite, a titanate of iron, lead and manganese, from Brazil: by Dr. E. Hussak and Mr. G. T. Prior.

Specimens were shown illustrative of the Senaite (by Mr. Prior), the silver iodide (by Mr. Spencer), and of the quartz pseudomorphs from New Zealand for Prof. Ulrich.

Mineralogical Society—Abstract of Receipts and Payments from 1st January to 31st December, 1897.

RECEIPTS.

	£ s. d.	£ s. d.
Balance from year 1896		49 18 0
Subscriptions:—		
(1) In advance	1 1 0	
(2) Current	43 0 10	
(3) In arrear	10 10 0	
		54 11 10
Entrance Fees and Compositions		48 6 0
Sale of Publications:		
(1) From Publishers	25 7 0	
(2) In Office	3 14 0	
		29 1 0
Authors' Extra Copies of Papers		5 9 9
Prof. O'Reilly for Illustrations		11 7 0
Dividends on Stock		9 6 3
		£207 19 10

PAYMENTS.

	£ s. d.	£ s. d.
Printing and Stationery		30 0 10
Illustrations		17 12 6
Purchase of Serials for Library		0 13 0
Binding Books for ditto		19 0 9
Clerical Expenses, *re* Removal and Care of Stock		2 2 0
Attendants' Fees at Meetings		1 1 0
Commission on Cheques		0 3 0
Investments and Brokers' Commission		59 6 3
Balance at Bank	£77 18 2	
,, in Office	0 2 4	
		78 0 6
		£207 19 10

Examined and compared with the vouchers and found correct. (Signed)

February 16th, 1898.

BENEDICT KITTO,
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LIABILITIES.

	£ s. d.
Printers' Account	46 12 9
Secretarial Postage for 1897	1 4 1
Excess of Assets over Liabilities	521 2 1
	£568 19 9

The number of Life Members on December 31st, 1897, was 44.

ASSETS.

	£ s. d.
Balance as above	78 0 6
Subscriptions unpaid	20 0 0
Stock in 2¾ Consols: £339 6s. 7d. at 112	447 8 7
Dividend on Stock, January 1898	2 13 2
Sale of Journals, due from Publisher	11 7 6
Due for Authors' Copies	9 10 0
	£568 19 9

MEMO.—The Stock and Publications and the Library are not included in the above assets.

(Signed) F. W. RUDLER,
Treasurer.

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THE MINERALOGICAL MAGAZINE

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MINERALOGICAL SOCIETY.

No. 54. JUNE, 1898. Vol. XII.

Augelite from a New Locality in Bolivia.

By L. J. Spencer, M.A., F.G.S.,

Assistant in the Mineral Department of the British Museum.

[Read November 16th, 1897.]

In a recent number of this Magazine (Vol. XI, 1895, p. 16) augelite was shown to be a definite mineral species, having the chemical composition $AlPO_4.Al(OH)_3$, and crystallising in the monosymmetric system. Owing to its rarity, or perhaps to its similarity in appearance to barytes, it has previously only been described[1] three times in mineralogical literature, and has been found at only two localities, namely, Westanå in Sweden and Machacamarca in Bolivia. It is therefore of interest to be able to record the mineral from a new locality.

The new occurrence is in the veta [=vein] Carmen of the silver mines at Tatasi and Portugalete,[2] in the province Sud-Chichas of the department Potosi. The specimen on which the augelite was found is one of a

[1] Des Cloizeaux (*Manuel de Min.* II, 1893, p. 454) examined cleavage flakes of the Swedish mineral; he gives a cleavage angle and some of the optical characters, but not enough to determine the system of crystallisation.

[2] Tatasi and Portugalete are mining villages which are connected by a level driven through the intervening mountain. H. Reck has described the Portugalete mines, *Berg.-und Hüttenm. Zeitung*, 1884, p. 125.

large suite of Bolivian specimens recently presented to the British Museum by my friend Mr. Malcolm Roberts, A.R.S.M., Administrator of Mines to the Compañia Guadalupe de Bolivia.

The specimen consists of an altered, acid volcanic tuff, with massive pyrites, and in cavities a considerable quantity of "feather ore," which is often aggregated in balls around indistinct crystals of black blende. In the cavities are also crystals of pyrites, chalybite, gypsum and calcite, together with white, powdery kaolin. The pyrites is cubical in habit, but sometimes aggregates of small cubes build up indistinct octahedra, as in fluorite. The gypsum is present as a few colourless needles with the forms $b\{010\}$, $m\{110\}$, $l\{111\}$ and $n\{\bar{1}11\}$. Calcite occurs as very minute thick-tabular crystals, with smooth, bright prism planes, and dull, rounded basal planes; they incrust the pyrites, or are penetrated and supported by the needles of "feather ore." In the kaolin a trace of phosphoric acid was found. The "feather ore," which is locally known as "paja quemada" (= burnt straw), consists of radiated or confused masses of very fine needles or hairs, which possess a certain degree of flexibility, and are of a dull iron-black colour. It was found to contain lead, antimony and sulphur. An analysis of "paja quemada" from Portugalete has been made by L. Kiepenheuer, and from this vom Rath[1] deduces the formula $2(Pb\frac{3}{5},Fe\frac{2}{5})S+Sb_2S_3$, calling the mineral jamesonite. Some of Mr. Roberts' specimens are, however, so intimately mixed with numerous minute octahedra of pyrites, as to suggest that the iron shown in Kiepenheuer's analysis may be due to the presence of this mineral.

The augelite, which is present in only small amount, is usually embedded in the massive pyrites, and sometimes encloses specks of this mineral. It is colourless and transparent, and shows the usual perfect cleavages. It so closely resembles barytes in general appearance, that it is only to be distinguished from this species by the measurement of the cleavage angles, and by the optical examination of cleavage flakes, namely, the determination of the extinction angles and the position of the optic axes. In a cavity, two small crystals showing faces and a third crystal very deeply etched were found; these measured about 1 mm. across.

One of these crystals shows three large bright planes, namely, $m(110)$, $m'''(1\bar{1}0)$, and a vicinal face near $c(001)$ in the zone $[001, 1\bar{1}0]$. The presence of this vicinal face, which is striated parallel to its intersection with $(1\bar{1}0)$, quite masks the symmetry of the crystal. Replacing the three edges formed by the above planes are narrow, striated, and some-

[1] *Sitz.-ber. niederrhein. Ges. Bonn*, 1879, XXXVI, p. 80.

what ill-defined planes of the forms $a\{100\}$, $n\{112\}$, and $d\{334\}$. The last of these has been previously given only as doubtful. The measured angles were:—

		Calculated.	Measured.
$mm''' = 110 : 1\bar{1}0$	...	113°14′	113°16′
$cm = 001 : 110$	...	77 52½	78 55
$cm''' = 001 : 1\bar{1}0$	...	77 52½	76 16
$dm = 334 : 110$	...	37 41	37 23
$n'm''' = 1\bar{1}2 : 1\bar{1}0$	...	46 45	47 1

The second crystal is also bounded by three large planes, namely, $m'(\bar{1}10)$, $m''(\bar{1}\bar{1}0)$, and a vicinal face quite close to $c(001)$, but in this case perpendicular to the plane of symmetry, and striated parallel to the axis of symmetry. The prism planes, as on the first crystal, are striated parallel to their mutual intersection, that is, parallel to the vertical axis. The new form $g\{910\}$ is represented by three narrow indistinct planes; $x\{\bar{1}01\}$ is present as a mere point, and there are small doubtful planes near the positions of $(\bar{1}16)$ and $(\bar{8}01)$. The angles measured on this crystal were:—

		Calculated.	Measured.
$m'm'' = \bar{1}10 : \bar{1}\bar{1}0$	...	113°14′	113°24′
$cm' = 001 : \bar{1}10$	...	102 7½	101 57
$cm'' = 001 : \bar{1}\bar{1}0$	...	102 7½	101 55½
$gm = 910 : 110$	...	47 3	47°, 47°, 47¼°

With this crystal the indices of refraction, as measured through the natural prism, were 1·5752 and 1·5893 for sodium light; and the optic axial angle[1] in air as seen through the basal plane $c(001)$, was determined with a microscope-stage goniometer devised by Prof. Miers to be 82½°.

Cleavage fragments, which had been goniometrically and optically determined, were found to have the chemical characters of augelite. The specific gravity of the crystals was determined to be 2·69, by the method previously mentioned in this Magazine (Vol. XI. p. 186).

In the previous paper on the augelite from Machacamarca, Bolivia, it was stated that there are three places called Machacamarca in Bolivia,

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[1] The acute bisectrix makes an angle of 11½° with the normal to $c(001)$. In the previous paper (*loc. cit.* p. 20) there is a slight ambiguity as to the position of the acute bisectrix. It lies "in the acute angle β," when β is taken as defined by Maskelyne (*Crystallography*, 1895, p. 436), but according to other authors this should read "in the obtuse axial angle β." According to Dana's notation (*System of Mineralogy*, 6th ed. 1892, p. xxxvi) it is $Bx_a \wedge c = +34°$.

and at the time it was not possible to decide from which of these the specimens came. According to information supplied by Mr. Roberts, it can now be stated to be the Machacamarca[1] which is "a few leagues to the north of the town of Potosi, and in the 'cercado' of that town." I have, however, been unable to find any published mention of this place. The Machacamarca about half-way between the towns of Oruro and Poopó, in the department Oruro, is not a mineral territory; it is here that the Oruro ores are amalgamated. A third Machacamarca, south-west of Palca, in the department Cochabamba, is given in the descriptions of the French Expeditions to South America of d'Orbigny (1826-1833) and Castelnau (1843-1847).

Mr. Roberts has been in correspondence with a mining friend of his at the Potosi Machacamarca, and has been able to send me a specimen from this place. In the quartzose matrix, the crystals of bournonite, bright octahedra of pyrites, and zinckenite (?), this specimen exactly resembles those previously examined; but it was only after searching at various times during a period of twelve months that a small crystal of augelite was at last found. This crystal, which is about 1 mm. in length, differs from those previously described in being more decidedly prismatic in habit, being elongated in the direction of the vertical axis. The forms present are $m\{110\}$ and $c\{001\}$, with narrow, indistinct $a\{100\}$ and negative pyramids $\{hhl\}$.

These occurrences of aluminium phosphate in the mineral veins of Bolivia are of interest in connection with the presence of cassiterite, but usual absence of apatite, as described by Stelzner.[2] It may perhaps be suggested that some of the occurrences of barytes mentioned by Stelzner (*loc. cit.* 1897, p. 111) may really be of augelite, though of course not all. I have myself, in the hopes of finding augelite, made optical and goniometric measurements of *barytes* from:—

(1). Mina Guernica at San Vicente (prov. Sud-Chichas, dept. Potosi), with bright crystals of tetrahedrite; also from San Vicente with cubo-octahedra of galena.

(2). Aullagas (prov. Chayanta, dept. Potosi), with pyrargyrite and stanniferous argyrodite (this vol. p. 6).

(3). Pulacayo mine, near Huanchaca (prov. Porco, dept. Potosi), with blende.

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[1] This is about 200 kilometers N.N.E. of the new locality now described for augelite.

[2] *Zeits. deutsch. geol. Ges.* 1892, XLIV, 531; 1897, XLIX, 51; see *Min. Mag.* X, 261, and this vol. pp. 46, 7.

Stanniferous Argyrodite from Bolivia: The Identity of the so-called "Crystallised Brongniardite" with Argyrodite-Canfieldite.

By G. T. Prior, M.A., F.G.S., and L. J. Spencer, M.A., F.G.S., Assistants in the Mineral Department of the British Museum.

[Read February 1st, 1898.]

THE occurrence in Bolivia of minerals containing the rare element germanium has been recently noted by Prof. S. L. Penfield. One of these minerals from Potosi, described by him in 1893,[1] has the chemical composition of the Freiberg argyrodite (the original source of germanium), but was determined to be cubic, and not monosymmetric, the system to which argyrodite was originally referred. To the supposed new mineral the name canfieldite was given, but when Weisbach's re-examination showed that the Freiberg argyrodite was possibly cubic, the name was transferred by Penfield to another mineral containing germanium, which he described in 1894.[2] This new mineral, Canfieldite, which came from La Paz, occurs as octahedra modified by dodecahedral planes, and is almost identical with argyrodite in all its physical properties, but differs from it chemically in that it contains tin isomorphously replacing germanium. The formula of argyrodite, as modified by Penfield's analyses of both the Bolivian and the Freiberg mineral, is $4Ag_2S.GeS_2$; that of canfieldite proper is $4Ag_2S.SnS_2$. The material actually analysed by Penfield was an isomorphous mixture of the two, containing about 7 per cent. of tin and nearly 2 per cent. of germanium. To such isomorphous mixtures he proposes that the name argyrodite or canfieldite should be given according as the germanium or the tin molecule predominates.

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[1] "Canfieldite, a new Germanium mineral, and on the Chemical Composition of Argyrodite." *Amer. Journ. Sci.*, 1893, XLVI, 107-113; Abstract, *Min. Mag.* X, 336.

[2] "On Argyrodite and a new Sulphostannate of Silver from Bolivia." *Amer. Journ. Sci.* 1894, XLVII, 451-4; Abstract, *Min. Mag.* XI, 40. Under this title Penfield's two papers are united in *Zeits. Kryst. Min.* 1894, XXIII, 240-8.

The material now to be described is interesting crystallographically on account of the twinning, and chemically in giving a different ratio of tin and germanium from that found in the original canfieldite. It is also found to be identical with the cubic crystals which Damour, in 1854, referred to brongniardite, a massive sulph-antimonite of silver and lead which he had previously described.

Stanniferous Argyrodite from Aullagas, Bolivia.

In 1894 Mr. Jacobo Aillon presented to the British Museum two specimens as examples of red silver from the mines of the Colquechaca Company at Aullagas,[1] a mining village, 15,500 feet above sea level, in the province Chayanta, of the department Potosi.

The specimens consist mainly of a cavernous mass of pyrargyrite, showing on the free surfaces short prismatic crystals which are generally rounded and indistinct, but sometimes exhibit the forms $a\{10\bar{1}\}$ and $e\{110\}$. Intermixed with the pyrargyrite is some massive brown blende, one or two thin plates of barytes, a few specks of iron pyrites, and a little grey powdery kaolin, while on one of the specimens there is a considerable quantity of stephanite, both massive and in bright crystals.[2]

The main interest of the specimens, however, is derived from the fact that encrusting the pyrargyrite, as a later growth, are numerous small dull black cubic crystals, which on analysis were found to be stanniferous argyrodite.

Crystallographic Characters.—The crystals are very symmetrical and regular, and for the most part are isolated and almost completely developed on all sides, though occasionally several are grouped together. Many of them, however, especially those of type (2) described below,

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[1] Aullagas is close to the town of Colquechaca, and lies east of the great lake Aullagas (or Poopó) and north of the town of Potosi. The mines here are noted for their very rich ore, consisting mainly of red silver and native silver. They have been described by H. Reck, *Petermann's geograph. Mitth.* 1867, 247; R. Peele, Junr. "The Silver Mines of Colquechaca, Bolivia," *Engineering and Mining Journal*, New York, 1894, LVII, 78, 100 (abstract, *Zeits. prakt. Geol.* 1894, 215); A. W. Stelzner, *Zeits. deutsch. geol. Ges.* 1897, XLIX, 89.

[2] On the crystals of stephanite the following forms were observed (the letters and indices are as given by Dana, *System of Mineralogy*, 6th edition, 1892):—

(i.) $c\{001\}$, $b\{010\}$, $m\{110\}$, $\pi\{130\}$, $q\{114\}$, $M\{113\}$, $P\{\bar{1}11\}$.
(ii.) c, b, $t\{023\}$, $k\{011\}$, $d\{021\}$, q, M, $h\{112\}$, P.
(iii.) c, b, m, t, k, M, P. All these crystals are twinned on $m(110)$.

Partial measurements of minute crystals implanted on an octahedron of the stanniferous argyrodite gave—

(iv.) c, b, $s\{012\}$, t, d, etc.
(v.) c, b, t, d, $\delta_1\{071\}$, etc.

are only shells of material implanted upon a nucleus of pyrargyrite, specks of which mineral they also sometimes enclose. These shells are easily detachable, and their inner surfaces show impressions of other crystals, and are sometimes encrusted with minute crystals of iron pyrites, and with extremely minute acicular crystals of an undetermined black metallic mineral. The habit of the crystals varies considerably. The following types can be distinguished :—

Fig. 1.

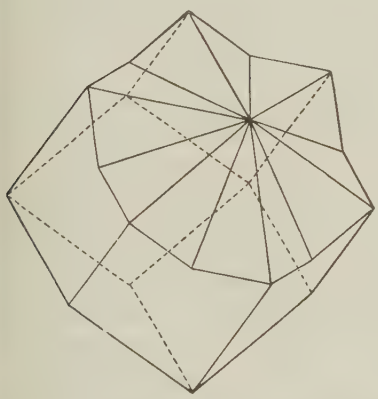
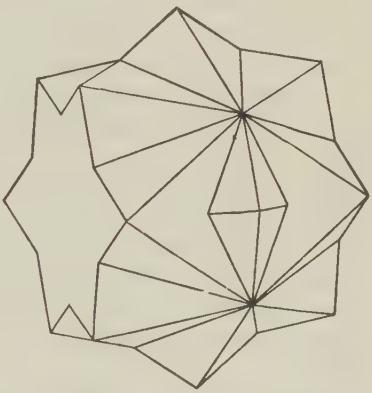


Fig. 2.



(1). *Simple* (i.e. *not twinned*) *octahedral crystals*, $o\{111\}$, *usually with narrow dodecahedral planes*, $d\{110\}$.

(*a*) Small, bright, and smooth crystals, with the dodecahedral planes very narrow or absent. These crystals, which do not exceed 0·5 mm. in diameter, occur only on the blende. On one crystal was measured $oo' = 70°25', 70°42'$; $od = 35°$ approx.

(*b*) Larger crystals, with dull, rough and pitted surfaces; dodecahedral planes are always present, and are occasionally more largely developed than the octahedral planes. These crystals average 1·5 mm. in diameter; the largest measures 5 mm. along the octahedral edge.

(2). *Dodecahedral crystals*, $d\{110\}$, *always twinned and never with octahedral planes.*

In size and surface characters these resemble type (1)*b*. The twin axis is perpendicular to $o\{111\}$. The following varieties can be distinguished, all of which occur with geometrical regularity :—

(*a*) Contact twins, showing no trace of the plane of junction. This twin occurs on gold, and is figured in most treatises on crystallography.

(*b*) Interpenetrating dodecahedra, with the two interpenetrating individuals at one end only of the twin axis, and at the other a simple crystal (fig. 1). Similar twins have been described by Sadebeck for blende.[1] The argyrodite "trilling" figured[2] by Weisbach is explained by these interpenetrating dodecahedra.

(*c*) Two interpenetrating dodecahedra, with re-entrant angles at both ends of the twin axis, as occur in sodalite.[3]

(*d*) Three interpenetrating dodecahedra, with two of the individuals twinned on two octahedral planes of the third individual (fig. 2). Here one pair of parallel planes is common to the three crystals, and four pairs are common to two crystals. A similar trilling, but far less regular, has been described by Sadebeck as occurring on blende.[4]

(*e*) Apparently simple dodecahedra, but on closer inspection showing numerous small projections on the faces due to small crystals in twin position.

(3). *An octahedron twinned according to the spinel law.*

Only one small indistinct crystal of this type was observed, this being on the specimen with the stephanite; all the other crystals on this specimen were of type (1)*b*. The re-entrant angle was measured as 37°—38½° (calculated 38°56′). This crystal was not examined chemically.

The difference between types (1) and (2) is very striking, and when considered in connection with the fact that twinning is mentioned in the two previous descriptions of argyrodite (from Freiberg and Bolivia), whilst Penfield's crystals of canfieldite were apparently simple, it would suggest that there is a difference in chemical composition. A separation of the two types for quantitative analysis was scarcely practicable, but as mentioned below (p. 10), both tin and germanium were found in the twinned as well as in the untwinned crystals, while the colour, fracture and streak were the same for all.

The very imperfect crystals of the Freiberg argyrodite, after being described originally as monosymmetric and later as orthorhombic, have, in consequence of Penfield's observations, been recently given as cubic

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[1] *Zeits. deutsch. geol. Ges.* 1869, XXI, pp. 634, 636; figs. 10, 11, Plate XVII.

[2] This figure is reproduced in Dana's *System of Mineralogy*, 6th edition, 1892, p. 150, fig. 2.

[3] C. F. Naumann, *Lehrb. d. Kryst.* 1830, II, p. 232, fig. 621. This figure is given in Dana's *System*, p. 429.

[4] *loc. cit.* p. 634, fig. 19.

and tetrahedral.[1] In the crystals at present described there is, however, nothing that suggests hemihedral development.

Physical Characters.—The mineral is opaque and of a dull iron-black colour. Crystals, when bright, as in the first habit (1)*a*, have a metallic lustre with a very faintly perceptible purplish tinge on the natural faces The streak is black and shining.[2] The fracture is even, with a finely granular appearance and a dull metallic lustre. The hardness is between that of gypsum and calcite. The mineral is somewhat brittle, but not extremely so. The specific gravity (weight of 1 cc.) is 6·19 at 18°C. as determined on 1·1021 gram of the material collected for analysis.

Chemical Characters.—In collecting material for analysis much care had to be exercised owing to the intimate association of the mineral with pyrargyrite. Each crystal was broken open and examined in bright sunlight under the lens, and also under the microscope. By the indications of streak and the character and colour of the fractured surfaces, pyrargyrite could be easily detected, and was then scraped away, whilst fragments which had a gritty feel under the knife, owing to the presence of pyrites, were rejected. The material so collected consisted of crystals of types (1)*b* and (2), with perhaps more of the latter. It was all taken off the specimen, on which no stephanite was found, since, in colour and streak, this mineral might have been confused with that which we were examining.

Heated in the closed tube, the mineral gives a sublimate of sulphur, and on intense ignition before the blowpipe, a pale lemon-yellow transparent gummy-looking sublimate of germanium oxide. When heated on charcoal before the blowpipe, a silver bead is left, and a white sublimate tinged with yellow is formed far out on the charcoal, while nearer the assay minute transparent fused globules of germanium oxide may be detected under the microscope.

Apart from these blowpipe tests, however, the identity of the mineral with stanniferous argyrodite was indicated by the following method of qualitative analysis:—

Two or three of the small crystals were introduced into a piece of hard glass tubing drawn out at one end and connected at the other with a hydrogen apparatus. On heating to redness in a slow current of the gas, the mineral yielded on both sides of the assay a deep reddish brown

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[1] A. Weisbach, *Neues Jahrb. für Min.* 1894, I, 98.

[2] The shining streak is obtained when a fragment of the mineral is crushed with a knife point on biscuit porcelain or on hard smooth paper; when the mineral is crushed on soft paper of loose texture, the streak is dull black, with a sooty appearance.

and black sublimate of germanium sub-sulphide and metallic germanium. The sublimate was dissolved in nitric acid, the solution evaporated to dryness, and the residue treated with a little ammonia into which sulphuretted hydrogen was conducted until it just dissolved. In this solution, on addition of a large excess of sulphuric acid and saturation with sulphuretted hydrogen, a bulky pure white precipitate of germanium bisulphide was produced. The residue in the combustion tube after the ignition in hydrogen was treated with nitric acid, and the tin separated from the silver as metastannic acid. This was dissolved in ammonium sulphide, and the tin precipitated as yellow sulphide on addition of acid. From the sulphide, spangles of metallic tin were obtained by reduction on charcoal before the blowpipe. In the filtrate from the metastannic acid, the silver was precipitated by hydrochloric acid. When examined by the above method, crystals of the two principal types, the twinned and the untwinned (see p. 8), were found to behave in a similar way, and to show the presence of both tin and germanium. In the case of the twinned crystals, 36 milligrams of material yielded about a milligram of oxide of tin, corresponding to about 2 per cent. of tin in the mineral.

In the quantitative analysis a similar method to that described by Penfield was adopted. The mineral was decomposed by prolonged digestion with fuming nitric acid, the liquid evaporated nearly to dryness, and the residue treated with hot water. The insoluble metastannic acid (containing also some germanium, silver and iron) was collected on a filter, and treated with ammonia, into which sulphuretted hydrogen was passed until the sulphides of tin and germanium passed into solution, leaving behind a little sulphide of silver and iron. The tin was then precipitated as sulphide by neutralising with sulphuric acid, and weighed as oxide, while the germanium in the filtrate was estimated as oxide on evaporating to dryness and treating the residue with nitric acid. After weighing, the oxide of tin was tested for germanium by reducing in hydrogen, and as a slight sublimate of germanium was obtained, the tin was estimated as metal.

In the original filtrate from the metastannic acid the silver was precipitated by hydrochloric acid, and the sulphur with barium nitrate. Before evaporating the filtrate, in order to avoid loss of germanium owing to the volatility of the chloride, the excess of hydrochloric acid was removed by means of silver nitrate; and at the same time the excess of barium was precipitated by sulphuric acid. The excess of silver was then removed by means of ammonium thiocyanate, and the filtrate evaporated to dryness. The residue was treated with ammonia into which

sulphuretted hydrogen was passed. The solution, containing germanium sulphide, was then filtered from the sulphide of iron, and evaporated to dryness. The residue was oxidised with nitric acid, and the germanium determined as oxide.

In a re-determination of the silver, made on 0·3197 gram from the same sample of powdered material, the mineral was decomposed by ignition in hydrogen, and the silver and tin in the metallic residue separated by means of nitric acid.

The result of the analysis made on 0·7608 gram is as follows (G. T. P.):—

			Atomic Ratios.		Calculated for $5(4Ag_2S.GeS_2)+2(4Ag_2S.SnS_2)$.
Ag	74·20	Mean of 78·89, 74·51	·6928	or 8	75·65
Ge	4·99		·0694	1·13	4·59
Sn	3·36		·0284		2·89
S	16·45		·5168	5·97	16·87
Fe	0·68				
Sb	traces				
	99·68				100·00

The so-called "Crystallised Brongniardite."

Under the name brongniardite, A. Damour in 1849[1] described a mineral from Potosi, Bolivia,[2] having the composition $PbS.Ag_2S.Sb_2S_3$ as determined by these analyses. On this original material no crystals occurred, but Damour considered that the mineral from its chemical composition should be isomorphous with the Binnenthal dufrenoysite ($2PbS.As_2S_3$) which he had recently investigated. At that time, however, having been misled by the association of cubic crystals of binnite with the mineral he had analysed, he was under the impression that dufrenoysite was cubic: he therefore suggested that should crystals of brongniardite be found, they would probably also be cubic. Accordingly when, a few years later, he[3] obtained from Louis Sæmann, a mineral dealer in

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[1] "Notice sur la Brongniardite, nouvelle espèce minérale." *Annales des Mines*, 1849, [iv], XVI, 227–231; and F. de Castelnau, *Expédition dans les parties centrales de l'Amérique du Sud*, 1851, Vol. V, p. 440.

[2] Not Mexico, as at first stated, and as quoted in the text-books.

[3] "Note sur la cristallisation de la brongniardite, espèce minérale." *Annales des Mines*, 1854, [V], VI, 146–7.

Paris, a specimen, also from Bolivia, of apparently the same massive mineral, in the cavities of which however were small octahedral crystals, he appears to have been somewhat too readily convinced, as the result of a blowpipe examination,[1] that the crystals contained the same elements as the massive material, and that both were identical with the brongniardite he had previously described. The crystals were determined to be octahedra symmetrically truncated on all the edges, and to be consequently cubic. Brongniardite is therefore described in the text-books as a cubic mineral having the composition $PbS.Ag_2S.Sb_2S_3$.

In the British Museum a specimen of "massive and crystallised brongniardite," which was acquired with the Allan-Greg collection in 1859, is accompanied by Sæmann's label giving the locality as Aullagas, Bolivia, and mentioning the results obtained by Damour in 1854. This specimen in external characters agrees precisely with the published description of Damour. Thus it shows small octahedral crystals, with narrow dodecahedral planes, in cavities in a massive mineral; and pyrargyrite and blende, which are mentioned by Damour, are also present in small amount.

The massive material consists for the most part of a mineral (presumably brongniardite) which was found to contain silver, lead, antimony and sulphur, and to have a specific gravity of 5·99. Intimately associated with this mineral is some galena, and in parts also miargyrite, which occurs both massive and as indistinct crystals. It is on the latter mineral that the octahedral crystals occur.

Now these dull black octahedra have exactly the appearance of the type (1)*b* of stanniferous argyrodite described in the preceding section (p. 7); the streak, too, and the even fracture, with its granular appearance and dull metallic lustre, are very similar. So striking, in fact, was the resemblance of the crystals, that the specimens presented by Mr. Aillon were at first regarded as brongniardite. Therefore, when the small black crystals on the latter had been shown to be a stanniferous argyrodite, it became necessary also to make a chemical examination of the so-called brongniardite crystals.

For this purpose the amount of material available was very limited. Two or three of the crystals, weighing altogether 23·2 milligrams, were heated in hydrogen and examined in the way described on p. 9. The reddish brown sublimate formed on the combustion tube was dissolved,

[1] He noted, however, that the yellow sublimate on charcoal obtained from the crystals was less marked than that furnished by the massive mineral.

and finally yielded a pure white bulky precipitate of germanium sulphide, while in the metallic residue the presence of tin was proved by the production of the yellow sulphide,[1] and that of silver by precipitation as chloride. The weight of the silver chloride amounted to 22·1 milligrams, corresponding to about 72 per cent. of silver in the mineral. No lead or antimony was detected. Thus the result of the above physical and chemical examination is to prove that the crystals which were referred by Damour to brongniardite are really identical with a stanniferous argyrodite.

Through the kindness of Prof. A. Lacroix we have been able to examine fragments from several of the specimens of brongniardite collected by the Castelnau Expedition (1843-7), and now preserved in the Natural History Museum at Paris. One of these (labelled Potosi) shows the small octahedra of argyrodite-canfieldite, and in every detail resembles in appearance the specimen described in this section.

As far as we are aware, the only other mention that has been made of crystallised brongniardite is by L. F. Navarro.[2] A specimen from the Cueva de Plata, Sierra Nevada, now in the Natural History Museum at Madrid, is described as showing cubes resembling argentite in appearance. Further examination would probably prove them to be that mineral.

Occurrence of Sulphostannates in Bolivia.

The occurrence at Aullagas of stanniferous argyrodite is of interest as illustrating the wide distribution of sulphostannates in Bolivia. Canfieldite is found at La Paz, stannite[3] at Guanuni and Potosi, franckeite[4] (a sulphostannate and sulph-antimonite of lead) at Chocaya and Aullagas, kylindrite[5] (another sulphostannate and sulph-antimonite of lead) at Poopó, while the somewhat unsatisfactory plumbostannite[6] of Raimondi (which may possibly be identical with franckeite or kylindrite) occurs at Moho, Peru, only a few miles from the Bolivian boundary. Thus

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[1] The precipitate was only a slight one, indicating that the mineral was in composition nearer to argyrodite than to canfieldite.

[2] *Anales Soc. Espanola Hist. Nat.* 1895, XXIV, Actas, p. 94.

[3] See Abstract, this vol. p. 46.

[4] A. W. Stelzner, *Neues Jahrb. Min.* 1893 II, p. 114; *Zeits. deutsch. geol. Ges.* 1897, XLIX, p. 141.

[5] A. Frenzel, *Neues Jahrb. Min.* 1893, II, p. 125.

[6] Also mentioned from Trinacria, near Poopó (*Zeits. deutsch. geol. Ges.* 1897, XLIX p. 693); and from Arangaro in Chili (*Bull. Soc. Fran. Min.*, 1895, XVIII, p. 340).

all the five naturally occurring sulphostannates at present known occur within or close to the borders of Bolivia, and, with the exception of stannite, are all peculiar to that region.

As recently emphasised by Stelzner,[1] the mode of occurrence of tin ores in Bolivia is of an exceptional character. Instead of occurring, as is almost invariably the case, in connection with deep-seated granitic rocks and in association with tourmaline, topaz, and other minerals containing boron and fluorine, usually considered as products of fumarole action, the tin ores of Bolivia are found accompanied by metallic sulphides[2] in the ordinary type of mineral veins, and in association with trachytic and andesitic rocks. It is just under such conditions that sulphostannates would be likely to be found.

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[1] *Zeits. deutsch. geol. Ges.* 1892, XLIV, p. 531; 1897, XLIX, pp. 51–142; Abstr. *Min. Mag.* X, 261.

[2] A case of the occurrence together of cassiterite and andorite is noted by us in the last number of this Magazine (Vol. XI, p 299).

Atacamite from Sierra Gorda, Chili.

By G. F. Herbert Smith, B.A.,

Assistant in the Mineral Department of the British Museum.

[Read February 1st, 1898.]

In this paper are recorded the observations made upon four exceptionally good specimens of atacamite in the British Museum, which have been submitted to careful study with the object of determining the geometrical and physical characters of the mineral with greater accuracy than has hitherto been possible. The axial ratios have been calculated with the utmost refinement, an attempt has been made to determine the crystallographic symmetry by a study of the etched figures, and the values of the principal indices of refraction have for the first time been obtained.

The crystals are peculiar in habit, owing to the striking development of the pyramid forms. It may be mentioned that crystals of atacamite usually present a combination of the forms $b(010)$,[1] $m(110)$ and $e(011)$, and occur as long prisms whose edges are perpendicular to (001). Sometimes only one corner, in which m and e meet, is visible, in which case, since $mm''' = 67°$ and $ee' = 74°$ approximately, they resemble regular octahedra. In the case of the four specimens under consideration, the summit of the crystals is altogether altered in appearance; the dome form e still occurs, though often very small, but the pyramid faces, instead of being, as before, almost entirely absent, or at any rate barely visible, now form the most striking feature.

The four specimens may be taken as two pairs, the individuals of each being identical in all respects except that of size. The two specimens of one pair are from Sierra Gorda, in the northern part of the Desert of Atacama; the other two are *probably* also from the same region.

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[1] The same letters are used for the faces as in Dana's *System of Mineralogy*, 6th edition.

1. *The axial ratios.*

The axial ratios given in Dana's *System of Mineralogy*, sixth edition, were calculated by Zepharovich from measurements made by himself and Klein on crystals from South Australia. There are in the British Museum numerous specimens from the Wallaroo mines. The crystals on these are good, but even the best cannot be compared with those from Sierra Gorda [1] Some pains, therefore, were taken to obtain accurate values of the ratios. The faces of the form $m(110)$ unfortunately give as a rule so many images, with so much overlapping, that accuracy was out of the question, and, as will be seen later, considerable variations were obtained in the value of the prism angle. The angles best available for measurement were found to be $rr''(111 : \bar{1}\bar{1}1)$, $rr'''(111 : 1\bar{1}1)$, $rr'(111 : \bar{1}11)$ and nr (121 : 111). Only faces which gave perfectly definite images were employed; for this reason only the angle nr can be derived from the form n, the faces being often too small to give a sufficiently bright image. The goniometer used was a large Fuess instrument reading to 10 seconds, and by estimation to seconds. Only three crystals were thus measured. None of the others observed attained to the same degree of excellence, and would, if used, have only compromised the real accuracy of the results. After properly weighting the means of the four angles mentioned above, the axial ratios were calculated by the method of least squares. The result is as follows:—

$$a : b : c = 0{\cdot}66130 : 1 : 0{\cdot}75293.$$

For comparison, a list of axial ratios obtained by other observers is added:—

$a : b : c = 0{\cdot}66126 : 1 : 0{\cdot}75149$	Zepharovich and Klein[2]
$0{\cdot}66129 : 1 : 0{\cdot}75453$	Des Cloizeaux[3]
$0{\cdot}6613 : 1 : 0{\cdot}7501$	Lévy[4]
$0{\cdot}6703 : 1 : 0{\cdot}7581$	Miller
$0.66186 : 1 : 0{\cdot}75302$	Brögger[5]
$0{\cdot}6683 : 1 : 0{\cdot}7506$	Zepharovich[6]

[1] Genth seems to have analysed similar crystals (see *Amer. Journ. Sci.* 1890, XL, 207), but no mention is made of any crystallographic or optical examination.

[2] *Ber. Akad. Wien*, 1873, 68(1), 120.

[3] *Nouvelles Recherches.*

[4] *Description d'une Collection de minéraux.*

[5] *Zeits. Kryst. Min.* 1879, III, 489.

[6] *Ber. Akad. Wien*, 1871, 63(1), 6.

Table I. gives the angles as calculated from the axial ratios and as observed :—

TABLE I.

Angle.	Calculated.	Observed Mean.	Diff.	Limits.	Edges.
111 : $\bar{1}\bar{1}1$ *rr''*	107°32′50″	107°32′21″	+29″	107°31′21″ – 107°33′44″	5
111 : $1\bar{1}1$ *rr'''*	52 50 34	52 51 7	—33	52 50 24 — 52 52 0	4
111 : $\bar{1}11$ *rr'*	84 34 40	84 34 32	+ 8	84 34 28 — 84 34 40	4
111 : 121 *rn*	18 23 46	18 24 13	— 27	18 23 19 — 18 24 52	7

The following are the calculated and observed values of *mm'''* on these crystals :—

Angle.	Calculated.	Observed Mean.	Limits.	Edges.
110 : $1\bar{1}0$ *mm'''*	66°57′12″	66°55′14′	66°41′40″—67°4′50″	5

2. *The face-indices and measurements.*

The general habit of the Sierra Gorda crystals is represented in fig. 1. *h* is a new and interesting form, whose faces are fairly large but invariably striated parallel to their intersections with *e*. As might, therefore, be expected, the observed values are not very accurate. This, however, will not account altogether for the very large variations noted; evidently vicinal faces are often present. The observed values fall more or less into groups, as given in Table II. It must be remarked that all these forms lie in the zone *me*. The simplest indices that can be assigned to *h* are (132), but the corresponding value is by no means the one most often met with, though it is the one observed when the face is least striated and the image most clear. On one crystal, indeed, two faces gave each two distinct images, which measurement showed corresponded to the forms (132) and (5·14·9), and could be plainly seen to be really double faces.

TABLE II.[1]

Angle.	Calculated.	Observed Mean.	Limits.	Edges.
110 : 253	41°42′ 5″	42°41′	41°49′—42′ 0′	5
110 : 5.14.9	45 10 32	45 16	44 33½—45 58½	12
110 : 132	47 5 13	47 22½	46 35 —47 30	5
110 : 4.13.9	49 7 26	40 57	49 47 —50 8	3
110 : 275	51 51 5	52 25	51 41 —53 10	4
$1\bar{1}0$: 132	95 16 7	95 8	93 54 —97 11	6

[1] In Table II. and the following tables the measurements were made on a smaller Fuess goniometer reading to half-minutes.

The following forms have been observed on these crystals:—

b(010) Only twice seen; probably then due to cleavage.

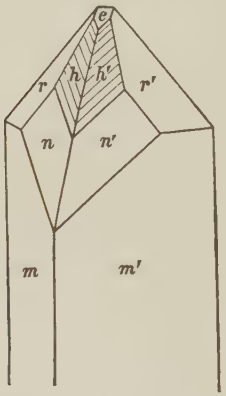
c(001) Infinitesimally small, no image given.

u(101) Seen twice only on one crystal, no image.

d(201) Very small, no image.

m(110) The principal prism form. As mentioned above, it gives multiple images.

Fig. 1.



s(120) Very small, no image.

e(011) Small, but images good.

r(111) Large faces: images beautifully distinct.

n(121) Faces not so large as in *r*, and often small: generally good images.

h(132), (5.14.9); see above.

The crystals used are from 3·5 mm. in length, but numerous smaller crystals are also present.

In Table III. will be found the calculated and observed values of the principal angles measured.

TABLE III.

Angle.	Calculated.	Observed Mean.	Limits.	Edges.
110 : $1\bar{1}0$ *mm'''*	66° 57′ 12″	66° 57′ 17″	66° 17′ — 67° 46′	12
111 : $\bar{1}\bar{1}1$ *rr''*	107 32 50	107 38 46	107 22 — 107 56	6
110 : 121 *mn*	33 33 20	33 31 32	33 14 — 33 52	11
110 : 011 *me*	70 37 22	70 37 14	70 26 — 70 52½	16
$1\bar{1}0$: 111 *m'''r*	71 35 26	71 34 0	71 1 — 71 54	14

Associated with Atacamite on the first pair of specimens, and often mixed with it, is another mineral, which on examination was found to be caracolite. It generally occurs as a crystalline crust adhering to the vein-stuff on which it lies, but a few crystals resembling hexagonal tablets were noticed. Caracolite from this region has already been described by Mr. Fletcher,[1] and observations made on the present material agree closely with his. Goniometrical measurements, taken alone, would suggest that this mineral belongs to the hexagonal system; but, on placing one of these tablets between crossed nicols in the position which should give a uniaxial figure, no such figure can be seen, nor is it possible by rotating the nicols to obtain any variation in the light transmitted through the crystal. If, however, a fragment be first crushed and then examined between crossed nicols, minute twin-crystals may be seen, as has been remarked by Professor Websky,[2] who, therefore, concluded that the crystals are really orthorhombic, and imitate hexagonality by twinning about a prism face after the manner of aragonite. Indeed, some of the prism faces on these hexagonal tablets are distinctly double faces, and give two images about 40′ apart; and hence caracolite is probably orthorhombic with the angle $(110 : 1\bar{1}0)$ approximately 60°26′.

A qualitative analysis of the crust showed the presence of lead, sodium, chlorine and sulphur, which is in accordance with the formula determined by Professor Websky.

The other two specimens are also of considerable interest. In the case of each, innumerable crystals of atacamite spring from a matrix of the same mineral, and are covered with a reddish iron oxide. They have evidently been exposed to the air, and are (except in cavities) much weather-worn.

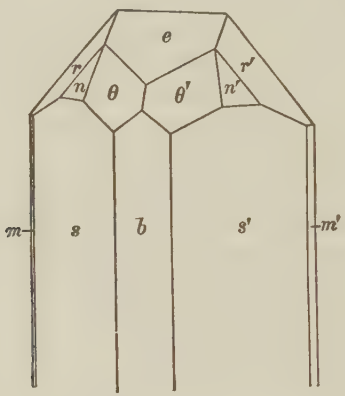
Curiously enough, in nearly the same position as on the Sierra Gorda crystals there is a new and peculiar form θ (fig. 2). It lies in the zone *bs*, whereas *h* is in the zone *bm*. Although the faces of this form are so large, only on two small crystals from a small cavity were they found sufficiently smooth to give images. Even when the other large faces gave good reflections, all that could be seen from the θ faces was a vague, dim blurr extending over some ten degrees. On the two crystals it was possible to measure five faces. They usually gave three images, whose relative positions varied with each face, and were never quite in the zone *bs* as they should be if the indices (273)—the simplest satis-

[1] *Min. Mag.* 1889, VIII, 172.

[2] *Ber. Ak. Berlin*, 1886, p. 1,045.

fying the conditions—are correct. There are probably three low vicinal pyramids on each face of θ. This form has apparently been noticed by Brögger[1] on a crystal from Chili. He suggested {142} as the probable symbol, but could obtain no measurements.

Fig. 2.



Besides θ there are four other new forms, namely, $\phi\tau\rho\sigma$; $\phi(131)$ has small faces giving single images, this form was only seen on the two crystals already mentioned; $\tau(890)$ or $(9{\cdot}10{\cdot}0)$, indices doubtful, presents itself as a minute face between m and t; and finally, on one crystal two faces $\rho(443)$, $\sigma(332)$ were seen in the zone mr. The angles determining the various forms are given in the following table:—

TABLE IV.

Angle.	Calculated.	Observed Mean.	Limits.	Edges.
120 : 273 $s\theta$	30° 34′ 24″	30° 5′	29°33′—30°48′	5
010 : 273 $b\theta$	35 32 37	34 56		1
120 : 131 $s\phi$	23 47 14	23 33½		1
010 : 131 $b\phi$	33 51 23	33 38	33°25′, 33°35′, 33°54′	3
110 : 890 mr	3 10 16	3 3	2°21′— 3°53′	10
110 : 443 $m\rho$	28 47 20	28 19	27°40′, 28°58′	2
110 : 332 $m\sigma$	26 2 0	25 30	24°36′, 25°40′, 26°15′	3

The other forms observed are:—

$b(010)$ Large; surface is rough, but gives good image.

$a(100)$ Very small, seldom seen.

$c(001)$ Very small, and always rounded.

[1] *Zeits. Kryst. Min.* 1879, III, 489.

x(140) Very small, but images fairly good.
k(130) Very small, diffused image.
s(120) Large; surface rough, but gives good image.
l(230) Very small, not often found, dim image.
t(560) Very small, not often found, dim image.
m(110) Small, but image distinct.
r(111) Very good face.
n(121) Not so large as r, but gives distinct image.
e(011) Large, and gives good image.
u(101) Very small, no image, only seen twice.

The crystals occur from 2-6 mm. in length.

The calculated and observed values of the principal angles are given in the following table:—

TABLE V.

Angle.	Calculated.	Observed Mean.	Limits.	Edges.
110 : $1\bar{1}0$ *mm'''*	66°57′ 12″	67° 6′ 42′′	65°57′ — 67°40′	23
120 : $\bar{1}20$ *ss'*	74 11 14	74 20 34	74 0 — 74 57	23
011 ; $0\bar{1}1$ *ee'*	73 57 16	73 56 0	73 40 — 74 10	6
111 : $\bar{1}\bar{1}1$ *rr''*	107 32 50	107 33 50	107 32 —107 36	6
111 : $\bar{1}11$ *rr'*	84 34 40	84 34 0	84 32 — 84 36	6
111 : $\bar{1}11$ *rr'''*	52 50 34	52 51 50	52 38 — 53 5	5
120 : 011 *se*	61 19 42	61 23 9	61 9 — 61 39	27
120 : 111 *sr*	40 28 18	40 22 38	40 2 — 40 38½	22

The following forms noted by other observers have not been found on these crystals:—

δ(023), i(0.10.9), o(021), g(031), q(221), z(331), w(992), f(211), y(321), and v(762).

3. *The etched figures.*

Crystals of atacamite, though sometimes figured as if completely developed, are rarely doubly terminated. In the British Museum there is one large crystal, about 4 cm. in length, from the Wallaroo mines, which shows one face of the form e at the other end. Also the few Sierra Gorda crystals, which have grown on their side, give with the goniometer faint indications of faces underneath. It is not, therefore, possible to determine by simple measurement whether the mineral is truly holohedral, and recourse must be had to some other method, such as etching.

Atacamite is readily dissolved by dilute acids. Hydrochloric, nitric and sulphuric acids were used, and all give the same results; the first

named is the least convenient, owing to the deposition of copper chloride crystals.

The form *m*, which occurs well developed on crystals belonging to the first pair of specimens, is quickly attacked by acids. Large cavities are formed, whose intersections with the face—sometimes a little curved—are isosceles triangles. The faces produced by etching are sufficiently smooth to give measurable images. The unequal side is a prism face, probably *k*; the two equal sides are faces in the zone *mn*, either (132) and (13$\bar{2}$) or (231) and (23$\bar{1}$). Measurements are obtained corresponding to both sets.

TABLE VI.

Angle.	Calculated.	Observed.
110 : 132	20°35′	20°10′, 20°22′, 20°15′
110 : 231	14 40½	14°4′, 15°42′
010 : 130 *bk*	29 47	28°40′

The figures appear to be quite symmetrical above and below, indicating the holohedral character of the crystals, but when the form *b* on crystals taken from the second pair of specimens is etched, the result is not quite in accordance with this view. On applying the acid, small vertical marks are seen, distinctly larger at the top than at the bottom. They grow in number, though not in size, till the face is covered with them, and finally the crystal splits up. This face is but slowly attacked by the acid.

The form *s* showed no figures at all.

As no trace of electric polarity was observed on heating the crystals, the balance of evidence is in favour of holohedral symmetry.

4. *The Optical Characters.*

The refractive indices for this mineral have hitherto not been determined. There is considerable difficulty in finding them, since they are too high for the total reflectometer, and the crystals are, if of any considerable size, only slightly transparent. It was found, therefore, impossible to get any result by employing the monochromatic light given by a volatilising salt; but, since the mineral absorbs all light but the green, measurable images for this light were obtained at minimum deviation with a Welsbach burner.

As none of the large prism forms have their internal angles small enough, faces unsymmetrical with regard to the principal planes had to be used, the labour of calculation being thereby considerably increased.

Since there is an excellent cleavage parallel to *b*, a prism consisting of the refracting faces *bm* on the first pair of specimens could be utilised, whilst the second pair gave the prisms *bs* and *be*.

The section of the wave-surface by a principal plane is a circle and an ellipse. The image corresponding to the former involves only one index, but the other involves two.

Consider the section parallel to the plane (001)—

$$\left.\begin{aligned} x^2+y^2 &= c^2 \\ a^2x^2+b^2y^2 &= a^2b^2 \end{aligned}\right\}$$

From the first equation we obtain the ordinary formula—

$$\frac{1}{c}=\gamma=\sin\tfrac{1}{2}(\mathrm{A}+\mathrm{D})/\sin\tfrac{1}{2}\mathrm{A},$$

And from the second—

$$\frac{1}{C^2S^2}-\tfrac{1}{2}\left(\frac{1}{C^2}+\frac{1}{S^2}\right)(a^2+b^2)+a^2b^2-\tfrac{1}{2}\left(\frac{1}{C^2}-\frac{1}{S^2}\right)\cos 2\phi\,(a^2b^2)=0.^1$$

Where $C=\cos\frac{1}{2}(\mathrm{A}+\mathrm{D})/\cos\frac{1}{2}\mathrm{A}$, $S=\sin\frac{1}{2}(\mathrm{A}+\mathrm{D})/\sin\frac{1}{2}\mathrm{A}$.

ϕ is the angle which the plane bisecting the prism angle makes with the plane of a ($a > b$); A is the angle of the prism, D the angle of deviation, $a={}^1/\alpha$, $b={}^1/\beta$, $c={}^1/\gamma$; $\alpha\beta\gamma$ are the three principal indices of refraction.

The three prisms already mentioned yield three pairs of equations to determine the three refractive indices.

Before giving these equations, there are two points worth noting:—Firstly, the two images can be easily distinguished by means of a nicol; for the image corresponding to the circle must be brightest when any reflected image is brightest, and *vice versâ:* just the contrary is the case with the other image. Secondly, in all three cases $2\phi = \mathrm{A}$, and therefore—

$$\frac{1}{C^2S^2}=\tfrac{1}{2}\left(\frac{1}{C^2}+\frac{1}{S^2}\right)-\tfrac{1}{2}\left(\frac{1}{C^2}-\frac{1}{S^2}\right)\cos 2\phi;$$

a convenient check on the arithmetical accuracy.

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[1] G. G. Stokes, "On a formula for determining the optical constants of doubly refracting crystals," *Camb. and Dublin Math. Journ.* 1846, I. 183; *Math. and Phys. Papers, Cambridge*, 1880, I, 148; *Cf.* Liebisch, *Physikalische Krystallographie*, Leipzig, 1891, equation at bottom of page 393.

The six equations and the data for deriving them are—

Prism bm; circle $A = 56°31\frac{1}{2}'$ $D = 69°0'$

$$\text{ellipse } D = 66°\ 9' \qquad \frac{1}{S^2} = \cdot 2912 \quad \frac{1}{C^2} = 3\cdot 3721$$

$$\gamma = \frac{1}{c} = \frac{\sin 62°45\frac{3}{4}'}{\sin 28°15\frac{3}{4}'} = 1\cdot 878 \qquad (1)$$

$$\cdot 9820 - 1\cdot 8316\ (b^2 + a^2) + a^2b^2 = -\cdot 8496\ (b^2 - a^2) \qquad (2)$$

Prism bs; circle $A = 37°\ 5\frac{1}{2}'$ $D = 36°25'$

$$\text{ellipse } D = 35°28' \qquad \frac{1}{S^2} = \cdot 2890 \quad \frac{1}{C^2} = 1\cdot 3832$$

$$\gamma = \frac{1}{c} = \frac{\sin 36°45\frac{1}{4}'}{\sin 18°32\frac{3}{4}'} = 1\cdot 882 \qquad (3)$$

$$\cdot 3997 - \cdot 8361\ (b^2 + a^2) + a^2b^2 = -\cdot 1364\ (b^2 - a^2) \qquad (4)$$

Prism be; circle $A = 53°\ 1\frac{1}{2}'$ $D = 59°20'$

$$\text{ellipse } D = 60°10' \qquad \frac{1}{S^2} = \cdot 2860 \quad \frac{1}{C^2} = 2\cdot 6423$$

$$\alpha = \frac{1}{a} = \frac{\sin 56°10\frac{3}{4}'}{\sin 26°30\frac{3}{4}'} = 1\cdot 861 \qquad (5)$$

$$\cdot 7556 - 1\cdot 4641\ (b^2 + c^2) + b^2c^2 = -\cdot 7085\ (b^2 - c^2) \qquad (6)$$

Hence $\gamma = 1\cdot 880$ ($\pm \cdot 002$).

This value is now substituted in (6) and β found—

$$b^2 = \cdot 2983$$
$$\beta = 1\cdot 831$$

From (2) and (4) after substituting for b we find a and α—

$$a^2 = \cdot 2892 \text{ and } \cdot 2879$$
$$\alpha = 1\cdot 860 \quad ,, \quad 1\cdot 863$$

Also direct from (5) $\alpha = 1\cdot 861$

Therefore $\alpha = 1\cdot 861$ ($\pm \cdot 002$).

The refractive indices are then for green light—

$$\alpha = 1\cdot 861$$
$$\beta = 1\cdot 831$$
$$\gamma = 1\cdot 880$$

Whence it may be seen that the axial plane is parallel to (100), and that the axis perpendicular to (010) is the acute bisectrix.

The angle between the optic axes for thallium light was measured in cedar oil, whose refractive index for sodium light was found to be 1·5312. Values were obtained varying from 95° to 97°.

The real angle between the axes $= 2 \sin^{-1} \frac{\beta}{\alpha} \sqrt{\frac{\gamma^2 - \alpha^2}{\gamma^2 - \beta^2}}$

which becomes in the present case 74°56′.

Further, the angle in oil is found on calculation to be 96°50′.

On Sphærostilbite.

By G. T. Prior, M.A., F.G.S.,

Assistant in the Mineral Department of the British Museum.

[Read April 5th, 1898.]

SPHÆROSTILBITE was one of a number of sub-species which Beudant, in his *Mineralogy*, published in 1832, separated from ordinary stilbite owing to slight differences in chemical composition. In a typical specimen from the Faroe Islands he describes the sphærostilbite as implanted upon ordinary stilbite, in the form of small globules, presenting a fibrous radiated structure and brilliant pearly lustre on the fractured surface. Unlike stilbite, it gelatinised with acids, and it also had a specific gravity (2·31) slightly higher than that of stilbite. According to the analyses given by Beudant, however, it differed in chemical composition so little from ordinary stilbite that in later text-books (Glocker, 1839; Breithaupt, 1847, &c.) it has always been referred to that species.

In Greg and Lettsom's *Mineralogy* (1858, p. 163), sphærostilbite is described under stilbite, and there occurs the statement, referred to by Dana (*System of Mineralogy*, 6th edition, p. 584), that according to Dr. Heddle sphærostilbite is "merely stilbite in the form of minute primary crystals disposed upon delicate radiating tufts of mesolite, the presence of which determines the spherical form, causes the gelatinisation in acids, and accounts for the slight variation in composition." In the above statement, instead of *mesolite* it is almost certain from the description that Heddle really meant *mesole*, for it was in 1857 that he published in the *Philosophical Magazine* the analytical work by which he showed that the delicate needles of mesolite and the radiated spheres with pearly lustre of mesole (or, as he preferred to call it, faroelite) must be considered as distinct species. Long before this, mesole had been referred by Haidinger (*Best. Min.* 1845, 529) to thomsonite, and this was confirmed by the examination of the optical characters made by Des Cloizeaux. As the result probably of his observations on mesole, Des Cloizeaux (*Min.* 1862, 419) was led to express the opinion with regard to sphærostilbite

that "it appears to result, from Beudant's description, that the name sphærostilbite and that of mesole have been applied to the same mineral," and that originally there had probably been confusion between the specimen described and that which was analysed.

Some years ago I had occasion to examine a number of doubtful specimens of zeolites belonging to a collection made by Miss Caroline Birley in the Faroe Islands. Amongst these specimens were some which were provisionally named sphærostilbite, owing to their resemblance to specimens so labelled in the British Museum. In appearance these specimens answered closely to Heddle's description, quoted above, if mesole be substituted for mesolite. Thus they consist of a sort of open network of confusedly-grouped and imperfect crystals, presenting pearly cleavage surfaces and resembling stilbite, disposed upon ordinary compact mesole (faroelite), the presence of which determines the spherical form. In most cases, between the crystal network and the compact radiated spheres of mesole is interposed a material more compact and less definitely crystallised than the network, but less compact and more crystalline than the mesole.

In the determination of doubtful specimens in Miss Birley's collection, reliance was chiefly placed upon examination of the optical characters. Small fragments crushed in oil on a slide were examined under the microscope with a $\frac{1}{12}$-inch immersion objective. In the case of the so-called sphærostilbites it was found that material taken from the base (mesole), from the intermediate portion, or from the upper and more definitely crystallised network, all behaved in the same way, and presented the optical characters, not of stilbite, but of thomsonite. Thus almost all the cleavage flakes obtained by crushing a fragment compensated with the quartz wedge across the length of the flake, and in convergent light showed the emergence of a positive bisectrix with the plane of the optic axes at right angles to the length of the flake and an optic axial angle of about 80°, as measured with an eyepiece micrometer. Intermixed with such flakes were only very few of apparently a somewhat more strongly doubly refractive mineral which showed no definite optic figure, and compensated with the quartz wedge along the length of the flake. The latter flakes doubtless consist of stilbite, the presence of which would account for the slightly higher silica percentage of faroelite over that of normal thomsonite. On close examination the material forming the crystal network was seen to consist of sheaf-like bundles, which are very similar to those of stilbite, and present a similar pearly cleavage surface; but, unlike that mineral, they have

square terminations, and thus resemble the sheaf-like aggregates—of comptonite (thomsonite) from Vesuvius. On many of the specimens of faroelite in the British Museum the square terminations can be seen as markings on the surface of the spheres. All the specimens of so-called sphærostilbite in the British Museum were found to have, like the specimens collected by Miss Birley, the optical characters of thomsonite, and not those of stilbite.

To confirm this determination, a quantitative analysis was made on 0·5299 gram of the crystal network carefully separated from the more compact spheres of mesole.

The result of this analysis is given under I., and under II. are the numbers obtained in a partial analysis made on 0·3733 gram of material from another specimen; while, for the sake of comparison, under III. is given the result of an analysis by Lemberg of a faroelite from the Faroe Islands, and under IV. the result of an analysis by the same analyst of a stilbite from the Faroe Islands.

		I.	II.	III.	IV.
SiO_2	...	40·69	41·47	39·98	55·26
Al_2O_3	...	28·63	28·69	29·62	17·36
CaO	...	12·98		11·77	7·55
Na_2O	...	5·66		4·87	1·93
H_2O	...	12·42	12·63	13·76	18·62
		100·38		100·00	100·72

The result of the analysis showed that the specimens of so-called sphærostilbite, which had been proved to have the optical characters of thomsonite, had also the chemical composition of that mineral.

Of the museum specimens three belonged to the Allan-Greg collection acquired in 1859, another was presented in 1858 by P. Dudgeon, Esq., a great personal friend of the late Prof. Heddle, while the third was purchased in 1858 from Mr. Alex. Rose, of Edinburgh. It was, therefore, shown that material from different sources which had been regarded as sphærostilbite must be referred to thomsonite, and not to stilbite.

The result of the above examination, made some years ago, was not deemed of sufficient importance to publish. Since that time, however, the museum has from time to time acquired specimens, labelled sphærostilbite, from American and Australian localities (Oregon, Flanders Island, Tasmania, &c.), and these, like the Faroe specimens, have, on optical examination, always proved to consist of thomsonite, and not of

stilbite. It therefore appeared to be desirable to place on record the fact that in many cases the name sphærostilbite has been applied in the past, and is still being applied, to material consisting of thomsonite, and not of stilbite.

At the same time the fact remains that stilbite can, and in fact does occur in spherical radiating aggregates. In the British Museum collection, besides the well-known "puflerite" from Puflerloch, Seisser Alps, there are specimens of stilbite in the form of spheres showing radiated structure from the Faroe Islands; Goschenen Alps; Rezbanya, Hungary; Arendal, Norway, &c.; but in these cases the mineral shows the optical characters of stilbite, and like stilbite does not gelatinise with acids.

Conclusions.

1. In all probability no such mineral as that described by Beudant as sphærostilbite exists, viz. a mineral occurring in spherical aggregates with a specific gravity of 2·31, gelatinising with acids, and having approximately the chemical composition of stilbite.

2. In all probability Heddle's sphærostilbite, described as consisting of stilbite implanted upon mesolite, is identical with the material described above, which consists of thomsonite in sheaf-like aggregates implanted upon the more compact thomsonite in the form of spherical aggregates (mesole or faroelite).

3. To avoid confusion the name sphærostilbite should be discarded, for it cannot be justly applied to specimens of stilbite in spherical aggregates, since they do not gelatinise with acids.

On Senaite, a new Mineral belonging to the Ilmenite Group, from Brazil.

By Dr. E. Hussak, of the Geological Survey of S. Paulo; and

G. T. Prior, M.A., F.G.S., Assistant in the Mineral Department of the British Museum.

[Read April 5th, 1898.]

THIS new ilmenite-like mineral, containing lead and manganese, was found in rounded fragments and rough crystals in the diamond-bearing sands of Diamantina, Minas Geraes, Brazil (at Dattas, Rio Cipó, &c.).

Crystallographic and other physical characters (E. H.).

The crystal system is rhombohedral, tetartohedral (trigonal rhombohedral of Groth). The vertical axis $c=0{\cdot}997$.

The mineral is very rich in faces. The rhombohedral planes are very bright, while the basal plane, owing to twinning, is generally uneven and, like the prism faces, dull.

Twins are very common. They are so-called supplementary twins on $\infty R2(10\bar{1})$, such as have been described by F. Becke on dolomite. The basal planes of the two individuals fall in one plane, and the prism faces meet at an angle of 30°.

Some of the measured angles approximate to angles obtained by Lévy for mohsite.[1] Thus—

	Senaite (Hussak)		Mohsite (Lévy)
$c(0001) : S(\bar{2}021)$	$=66°38\frac{1}{2}'$	...	67°30′
,, $: r(10\bar{1}1)$	$=49\ \ 4$	...	50 21
,, $: z(40\bar{4}1)$	$=77\ 33\frac{1}{2}$	...	78 18

The mineral has no cleavage. The fracture is conchoidal, the hardness just above 6 (splinters scratch glass). The specific gravity is variable; that of the compact grains, apparently perfectly fresh and homogeneous,

[1] *Phil. Mag.* 1827, I, 221. In this paper no chemical characters are given, and it is only doubtfully that the mineral has been since referred to ilmenite.

used in the analysis, was 4·78 (G. T. P.), while that of decomposed crystals was as low as 4·22 (W. Florence), and that of undecomposed crystals with cavities as high as 5·301 (E. H.). The colour of the mineral is black, and the lustre sub-metallic. The colour of the powder is brownish black. In very thin splinters the mineral is transparent, with an oil-green to greenish-brown colour. It is weakly doubly refracting, non-pleochroic, and optically uniaxial. The mineral is not magnetic.

Some of the crystals are partially decomposed. In these cases the prism faces are covered with a brown coating of limonite, while the rhombohedral faces have a yellow earthy crust consisting of titanic acid, with only a trace of iron.

Chemical Characters (G. T. P.).

The mineral is infusible before the blowpipe, but after heating loses its lustre and shows signs of alteration, It is decomposed by hydrofluoric acid, by boiling sulphuric acid, and by fusion with hydrogen potassium sulphate. The material used in the quantitative analysis consisted of rounded fragments (not crystals) apparently quite fresh and homogeneous. The mineral was fused with hydrogen potassium sulphate. On treating with cold water and filtering, most of the lead was separated as sulphate, while the remainder in the filtrate was precipitated as sulphide by sulphuretted hydrogen. The titanic acid was thrown down by long-continued boiling, while carbonic acid was passed through the liquid. The iron was then precipitated by sodium acetate, and the manganese by ammonium sulphide.

The ferrous iron was determined by decomposing the mineral with hydrofluoric and sulphuric acids in an atmosphere of carbonic acid, and titrating with potassium permanganate.

The percentage of titanic acid was checked by a colorimetric determination which gave 56·85.

Under I. is given the result of the complete analysis made on 0·6382 gram, and under II. that of a preliminary analysis made on 0·3247 gram of a different sample.

	I.	Molecular ratios	II.	III.	IV.	V.
TiO_2	=57·21	·6962	56·11	59·20	63·31	69·51
PbO	=10·51	·0474	11·43			
FeO	= 4·14	·0562		4·90	35·99	28·67
Fe_2O_3	=20·22	·1267	25·16	32·11		
MnO	= 7·00	·0988	7·81	1·73		1·41
MgO	= 0·49	·0123			0·82	0·32
SnO_2	= 0·11	·0073		SiO_2 1·16	1·25	0·44
	99·68			99·10	101·37	100·45

The numbers lead to no very satisfactory formula. If all the iron be considered to be present as FeO, and the manganese as MnO_2 instead of MnO, we get approximately $(FePb)O.2(TiMn)O_2$; but in the present state of our knowledge of the composition of ilmenite, it would be rash to insist on such a formula. The amount of titanic acid is much too great for the ordinary ilmenite formula $FeO.TiO_2$ advocated by Penfield.[1]

For the sake of comparison, under III. is given the result of an analysis by Mackintosh[2] of an ilmenite from Brazil; and under IV. the result of an analysis by Peek[3] of a so-called ilmenite from Bedford Co., Virginia. In both of these analyses the amount of TiO_2 is too great for the ordinary formula of ilmenite. Under V. are given the numbers obtained in the analysis of Janovsky's iserite[4] which correspond to the formula $FeO.2TiO_2$.

The low specific gravity (4·78) of the material analysed with respect to that of the crystals (5·3) would suggest that it was altered. It gave, however, no loss on ignition, and showed no external signs of decomposition. A crystal fragment with specific gravity 5·08 showed on analysis the presence of iron, titanium, lead and manganese, and in appearance was precisely similar to the material quantitatively analysed.

The name senaite has been given to the mineral in honour of Prof. Joachim da Costa Sena, of Ouro Preto, Minas Geraes, Brazil, from whom the samples of sand containing the mineral were received.

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[1] *Amer. Journ. Sci.* 1897, IV, 108.
[2] *Amer. Jour. Sci.* 1885, XXIX, 342.
[3] *Amer. Chem. Journ.* 1897, XIX, 232.
[4] *Ber. Akad. Wien.* 1880, 80 (1), 34.

Note on peculiar Quartz-Pseudomorphs found at the Owera Mine, Opitonui, North Island, New Zealand.

By Prof. G. H. F. Ulrich, F.G.S.

[Communicated by Professor Judd, C.B., F.R.S.]

[Read April 5th, 1898.]

THE Owera Mine is opened on a line of lode or reef consisting of small auriferous quartz veins traversing decomposed hypersthene-augite-andesite. The quartz of the veins is highly ferruginous, and full of little patches of brown hæmatite indicating decomposed pre-existing pyrite, remnants of which are occasionally observed. It is in connection with the veins in the soft country rock and near the surface that the pseudomorphs under notice are found, and it seems probable that they owe their origin to infiltration of silica into cavities left by removal of calcite, though none has the actual form of a crystal of that mineral, which, in fact, is quite absent at the place Yet the specimen (No. 2) found with some of the pseudo-crystals tends to support this supposed origin, the hollows and, more clearly, wax impressions of them showing that the removed crystals were scalenohedra. On some of the pseudo-crystals here and there an angle occurs, as measured by the hand-goniometer, approaching one or other of the terminal scalenohedral angles measured on a wax impression, but there is no further resemblance to this form. In general development and appearance, save colour, these pseudomorphs are much like the chalcedony "enhydros" found many years ago in the decomposed granite bottom beneath gold drift of a miner's claim in the Beechworth district, Victoria. There, however, many of the discovered pseudo-crystals enclosed fluid and moveable gas bubbles, while in none of those now under notice can such be seen. Yet it is probable that some of the kind do occur, and would therefore be true "enhydros." Two of the pseudo-crystals were cut in half. In one the interior cavity is virtually filled up, while the other shows, like many chalcedony geodes and Beechworth enhydros, a central cavity with drusy walls of quartz crystals. The appearance of a shining tracery on the

planes of the pseudo-crystals, judging from fine transverse striations, is doubtless due to the prism faces of small quartz crystals that lined the walls of the original cavities, while the dull parts between belong to quartz crystals grown into the cavities at all angles up to 90° to the walls. In fact, microscopic examination in convergent polarised light of thin sections, cut parallel to any of the planes of a pseudo-crystal, proves that the mass of each is compounded of small crystals of different optical orientation, and amongst these there are many cut at right angles to the principal axis, showing fine interference figures in which the positive optical character of the quartz can be especially well observed.

It may be mentioned in this connection that in other parts of the North Island gold fields, notably at Tirua, free silica produced through the decomposition of rhyolitic rocks has been deposited as "opal," forming a kind of granular rock in which many grains, here and there, show the colours of real precious opal; and some of these having been found of good size, mining for precious opal in the district has been spoken of as a possibly profitable industry.

NOTES AND COMMENTS.

WE note with regret the death, on March 30th, 1898, of Mr. James I'Anson, of Darlington, a well-known engineer who was for many years a member not only of the Mineralogical Society, but of its Council. In conjunction with Mr. E. A. Pankhurst he published in this Magazine an interesting paper on "Some Artificial Forms of Silica," illustrative of the structure of Agates and Chalcedonies.

The deaths are also reported of two eminent foreign mineralogists—Dr. Karl Ludwig Fridolin von Sandberger, who was elected a Foreign Member of this Society in the year 1879; and Dr. Christian Wilhelm Blomstrand, of Lund.

Dr. Sandberger was until recently Professor of Mineralogy and Geology in the University of Würzburg, where he was appointed in 1863. His name will always be associated with the remarkable advances in the study of ore-deposits, which were initiated by his researches. His view that the contents of metalliferous veins are derived by lateral secretion from the country rock was defended by careful observations upon mineral paragenesis and analyses of the minerals in the neighbourhood of the lodes, especially in the mining region of Schapbach. His *Untersuchungen über Erzgänge* was a most valuable contribution to the subject, and for the last 25 years his researches have been well known to all mineralogists. Prof. Sandberger was also the author of numerous papers on mineralogical and geological subjects, especially on fossil mollusca, published in the *Neues Jahrbuch f. Mineralogie* and in the geological journals. He died on April 11th, 1898, at the age of 72 years.

Dr. Blomstrand was Professor of Chemistry in the University of Lund, and his name is connected with numerous analyses, chiefly of Scandinavian minerals, compounds of the rare earths and of uranium, in which difficult subject he had no superior in skill and experience among contemporary chemists. He died on November 5th, 1897, in his 71st year.

Among recent appointments we note that of Mr. L. V. Pirsson to the Professorship of Physical Geology in Harvard University, and of Dr. J. L. C. Schroeder van der Kolk to the Professorship of Mineralogy in the Polytechnikum of Delft.

Professor Hintze, of Breslau, has, we are glad to see, entered upon the second volume of his great handbook, to which we have previously called attention. The first Lieferung, which has been recently published, contains accounts of diamond, graphite, sulphur, the arsenic group and iron, treated in the exhaustive and elaborate manner, both as regards description of properties and of localities, with which the silicates have already been described in the first volume.

All mineralogists will welcome the fourth edition of Professor Groth's *Tabellarische Uebersicht der Mineralien*, a work so well known to students and to curators of collections that it requires no recommendation beyond its own name.

The new edition differs from the last in having prefixed to each mineral group a general introduction which will be found of the greatest value to students as a survey of the most recent discoveries regarding the chemical constitution of minerals, and still more as an expression of the author's own interpretation. The crystallographic symmetry of each mineral is also more definite. The general arrangement of the book remains much the same as before.

We have received the following books:—

T. Fletcher. *The Commercial Uses of Coal Gas.* Fletcher, Russell and Co., Ltd. A supplement to the same author's *Coal Gas as a Fuel*, containing useful notes on the applications of coal-gas in a number of industries.

J. W. Leonard. *The Gold Fields of the Klondike.* T. Fisher Unwin. A book which instructs the fortune hunter how to get there and how to outfit.

OBITUARIES.

Alfred Olivier Des Cloizeaux.

PROFESSOR DES CLOIZEAUX, in whose death we had last year to deplore the loss of one of our most eminent Foreign Members, was born in 1817.

Imbued from childhood with a taste for mineralogy, he came in his student's days into contact with Lévy, Dufrénoy and Senarmont. After holding some minor appointments he was elected Maître de Conférences at the Ecole Normale in 1857, succeeded Delafosse as Professor at the Sorbonne in 1873, and at the Musée d'Histoire Naturelle in 1876, where he was made Honorary Professor in 1892.

In this brief notice it is not possible to do more than indicate in outline a small part of his extensive contributions to science. A complete list of publications is appended to the full and appreciative notice of Des Cloizeaux's life and works issued by his successor, Professor Lacroix, in the 20th volume of the *Bulletin de la Société Française de Minéralogie*, from which the above details are borrowed. His best known work is doubtless the *Manuel de Minéralogie*, which was originally undertaken with the intention of translating Brooke and Miller's edition of Phillips' *Mineralogy*, by which he had been much attracted. The work, however, assumed such large dimensions when he began to incorporate his own researches, that although the first volume was published in 1862, the first part of the second volume did not appear till 1874, and the second part in 1893. At the time when the first volume was issued, this book was quite remarkable for the immense amount of new information which it contained relating to the optical characters and the crystal measurements of minerals. Long tables of calculated and measured angles were a prominent feature of the descriptions, and the marvellous spherical projections which accompanied them added greatly to the utility of the book, and did much to render this mode of representation popular among mineralogists.

But Des Cloizeaux's most solid and enduring contributions to science were his memoirs on the optical properties of minerals, which really put quite a new and very powerful instrument of research into the hands

of investigators. These researches were originally begun under the direction of Biot; the best known among them are the discovery and definition of the dispersions in the monoclinic system, and the remarkable study of the variations introduced into the optical characters of crystals by change of temperature. Des Cloizeaux was the first to determine these characters and their variations for a very large number of substances, among which the most important were the felspars.

It is difficult now to realise how novel were the investigations which have since become familiar in all text-books of Mineralogy; to appreciate the profound influence which Des Cloizeaux's work exerted upon the science one must read again the text-books anterior to the date of his classic memoir on the use of the polarising microscope, and see how meagre were those optical data, without which no mineral description is now complete.

Among the more purely crystallographic memoirs the monograph on the form and structure of quartz stands as one of his most masterly works, and represents a vast amount of research. Among other contributions to Mineralogy, perhaps the best known and those which have exerted most influence on the science are the studies of the chondrodites, of microcline, of zoisite, and of the rhombic pyroxenes and amphiboles.

Des Cloizeaux was in 1870 first President of the Mineralogical Society of France, of which he was one of the founders; he was elected Member of the Institute in 1869, and President of the Academy of Sciences in 1889. He was a Foreign Member of this Society from the time of its formation.

His life was devoted with extraordinary assiduity to the study of minerals almost up to the day of his death, which took place on May 7th, 1897. H. A. M.

Emeritus-Professor M. Forster Heddle, M.D., F.R.S.E.

Matthew Forster Heddle was the younger son of Robert Heddle, of Melsettar, Hoy, Orkney, and was born there in 1828. The family were of Scandinavian descent, and it is doubtless to this strain that we may attribute much of the self-reliance, hardihood, energy and love of adventure which characterised Heddle in after life. These qualities were further developed by an out-door life, largely spent in clambering amongst the dangerous cliffs, or in boating alone amongst the geos, stacks and wild sea inlets, around his native island.

He was sent to Edinburgh to be educated, and he went first to the

Academy, and subsequently to Merchiston Castle, in connection with which schools there exist records of his stay in 1840-4. Many stories are told of him by his former schoolfellows. Most of these show that Heddle's well-known characteristics had begun to manifest themselves at an early period. One story illustrates his readiness to take up the cudgels in defence of any of the weaker of the boys who happened to be bullied by another, a congenial occupation in which Heddle's bodily strength and pluck were usually turned to good account. Others bring Heddle's histrionic talent into prominence, and tell us of his wonderful gifts as a romancer. Some of the anecdotes clearly show that, even as a lad, one of his most strongly-marked characteristics was that of a collector. It was this propensity which led to his becoming one of the founders of a School Natural History Society, whose chief business seems to have been, as usual in such cases, the making of collections of butterflies, birds'-eggs, shells and plants. It is said that young Heddle made a very good collection of Scottish plants, among which those of the mountains figured prominently. He gained a school prize for this herbarium, and it would appear from what can be gathered of this part of his early history, that he seemed at this period to be in a fair way of passing from the grade of a mere collector of plants to the higher stage of a student of botany. But an untoward accident occurred, which led to his energies being diverted from this into another channel. Heddle tells us that he lent the herbarium to a friend, who, when travelling across a stream with it, accidently let it fall into the water, whereby the collection became irretrievably ruined. He resolved, after this incident, to devote his energies to collecting something that could not be so easily spoiled, and henceforth became a collector of minerals. From that day forth to the end of his life nearly the whole of the time and energy at his command, and almost all the money he could obtain, were devoted to the one single object of collecting great quantities of the largest and finest specimens of minerals that were anywhere to be got. This eventually led to his amassing a remarkably fine general collection of minerals, comprising many specimens of unusually large size, and also to his getting together from the mountains, coasts and mines of Scotland, what is certainly the very finest local collection of minerals obtained from a single district by any one man. This Scottish mineral collection, which may be regarded as the crowning work of Dr. Heddle's life, eventually became, partly by purchase, and partly by gift, the property of the nation; and it is now fittingly displayed in the Gallery of Scottish Geology and Mineralogy in the Edinburgh Museum of Science and Art, where it was arranged chiefly under the direction of Dr. Heddle himself.

Returning to the chief events of Dr. Heddle's early life, it may be mentioned that from school he passed to the Edinburgh University, where he entered as a medical student, and where he obtained what was then, and still is, that best of all forms of education for a scientific career which training as a medical man confers upon a student. After going through the prescribed course of instruction, he went for a time to Clausthal, and then to Freiberg, where he studied chemistry, and extended his knowledge of mineralogy. Those who carefully study Dr. Heddle's scientific writings, and especially such as deal with geological topics, cannot fail to perceive in them many evidences of the extent to which his modes of thought were impressed by the German school of teaching of that period.

Returning to Edinburgh in 1851, he graduated M.D., taking as his thesis "The Ores of the Metals." After graduation he commenced medical practice in one of the poorer parts of Edinburgh. Those who knew Dr. Heddle are well aware that Nature had been bountiful to him in many ways. He might have done well as a lawyer, or as an actor, or as a novelist; he certainly was a born collector; and it is equally certain that he took the keenest possible interest in everything that related to Mineralogy; but assuredly he lacked some of those special gifts and acquirements whose possession leads to eminence in the medical profession. As this medical work proved entirely uncongenial to his tastes, he took the first possible opportunity of abandoning it, and of taking to work in its stead which was more to his mind.

It was soon after this (1856) that he went to Faroe, where he collected a large quantity of the fine zeolites which occur in the vapour cavities of the tertiary volcanic rocks there. These formed an important part of the basis of his general collection just referred to, and it was from the numerous duplicates then obtained that he afterwards drew a large supply of the materials used in acquiring other minerals by exchange. In 1858 he took an important share in bringing out a new Edition of Greg and Lettsom's *British Mineralogy*. In 1856 the Professor of Chemistry at the University of St. Andrew's became unable to carry on his teaching work, whereupon Dr. Heddle became his assistant, and in 1862 succeeded to the Professorship. While there he made, or had made, a large number of analyses of minerals, of which nearly 600 are exhibited in the Edinburgh Museum, alongside of the Scottish minerals to which they refer. He held the post at St. Andrew's, from first to last, for a period of 23 years.

Near the close of 1883 he was persuaded by a well-known financier to leave his professional duties and go to South Africa in connection with

some mines there. After taking due precautions in regard to possibilities in the future in connection with this new move—a proceeding in which Dr. Heddle's legal acumen stood him in very good stead—he relinquished his professorship, and went to South Africa. On his arrival, however, he found himself unable to endorse some of the statements which had been made regarding the prospects of the mines, and accordingly he left the country and returned home. Having proved successful in the lawsuit which ensued, he settled down again at St. Andrew's for the remainder of his life, devoting himself to his work amongst the Minerals of Scotland, and to the preparation of his long-promised book dealing with them.

Dr. Heddle's name is well known to the readers of the *Mineralogical Magazine* as the author of an extensive series of papers on the "Geognosy of Scotland." He also contributed to the *Proceedings of the Royal Society of Edinburgh* several other papers equally valuable, which were entitled "Chapters on the Mineralogy of Scotland." For one of these, dealing with the Rhombohedral Carbonates, he was awarded the Keith Medal in 1878. He was the author also of a large number of other papers dealing with Mineralogy and Geognosy; and he produced single-handed a geological map of Sutherland, which was for a long time the standard map of its kind, and upon which many subsequent writers have drawn for large supplies of both facts and ideas.

Dr. Heddle was at one time President of the Geological Society of Edinburgh. It was while he occupied this post that he was chiefly instrumental in urging the Government of the day to commence a Geological Survey of Scotland. He was the second President, and one of the founders, of the Mineralogical Society of Great Britain.

Probably the two chief works in connection with which Dr. Heddle's name will be best known to posterity will be his grand collection of Scottish Minerals in the Edinburgh Museum, and his book on the *Mineralogy of Scotland*, which he worked at for many years, and of which the manuscript and the drawings of crystals were nearly completed before his death. Dr. Heddle requested his friends, Mr. Alexander Thoms and the writer of this notice, to co-operate in completing the book, and in getting it published. This is being done, and by the end of the present year (1898) it will appear as a royal octavo volume of about 400 pages of letterpress, and illustrated with about one hundred and twenty plates of eight figures each, representing Scottish minerals, which were drawn almost entirely by the doctor's own hands.

Dr. Heddle died on the 19th November, 1897, and was buried in the grounds of the fine old Cathedral of St. Andrew's. J. G. Goodchild.

Albrecht Schrauf.

Although not more than 60 years of age at the time of his death, which took place on November 29th, 1897, the Professor of Mineralogy in the University of Vienna had been failing in health for a considerable time, and his decease can have been no surprise to his friends. Since 1896, when he lost the sight of one eye by the accidental entry of direct sunlight into the telescope of his goniometer, he had become partly incapacitated.

Educated in Vienna under the influence of Grailich, he was early attracted by the crystallographic methods of Miller, studied physics under von Ettingshausen, and so laid the foundation of what in after life proved to be his chief study, and the one on which in 1860-8 he published his well-known text-book, *Physikalische Mineralogie*. He became successively Assistant in the Hofmineralien Cabinet of Vienna, Professor of Mineralogy at Lemberg, Keeper of the Hofmineralien Cabinet, and in 1874 succeeded Reuss as Professor in the University. In his younger days he was closely associated with the Archduke Stephan, whose fine collection he studied for the preparation of a catalogue, and to whom he dedicated his *Atlas der Krystallformen*, which was intended to be a systematic representation of all the known forms of minerals. This work was never finished, but the five parts which were completed remain as a monument to his industry. The list of Schrauf's published books and papers (about 120) sufficiently indicates the wide range of his studies, and the active mind which has been lost to mineralogy by his death. His more prominent memoirs were devoted to (1) the physical and geometrical properties of crystals, (2) the atomic structure of crystals, and (3) mineral paragenesis. The last subject was always an important feature of his course. As a teacher Schrauf was extremely successful, and those who enjoyed the privilege of visiting his Institute under the personal guidance of the Professor were deeply impressed by the completeness of his system and educational methods. The details of Schrauf's life can be gleaned from a sympathetic biographical sketch published by one of his most distinguished pupils, Professor R. Scharizer, of Czernowitz.

His friends and pupils are desirous of raising a monument to his memory, and Dr. A. Pelikan is willing to receive subscriptions for this purpose at the Mineralogisches Institut, Universität, Wien. H. A. M.

REVIEWS.

Goldschmidt (V.). *Krystallographische Winkeltabellen.* Berlin, 1897.

Since the early editions of Phillips' *Mineralogy*, various text-books and works of reference have appeared, each containing more and more complete lists of crystal angles. But the number of angles that can be calculated between all the pairs of faces of such complicated crystals as occur in the mineral kingdom seems almost boundless, and it might be thought hopeless to make these lists even approximately complete.

This is, however, what is done by Dr. Victor Goldschmidt in the present volume, and it is only possible by means of the theodolite, or two-circle goniometer, of which he is an ardent champion. Every practical crystallographer will realise how much easier it is to identify the faces of a crystal by comparing their measurements with a table of angles than by calculating out the indices of each face from the measurements; but it may be that the angles actually measured are not those given in the available tables. With the two-circle goniometer, however, if the crystal be adjusted in the orthodox position, each face is fully defined by two angles which are directly read upon the goniometer circles. Dr. Goldschmidt has not hesitated to face the vast labour of calculating all the angles (about 22,000 in number) which belong to the known faces of minerals, a work which with the help of computers occupied him for nearly two years. The result is the present volume, with the help of which any student using the theodolite goniometer can identify any known face by a direct reading, and can determine new faces without much trouble. These tables will do much to popularise the new method of crystal measurement, which is now beginning to find many adherents. The writer can speak from personal experience of its utility in certain cases where measurement would be impossible without its aid.

H. A. M.

Fuchs (C. W. C.). *Anleitung zum Bestimmen der Mineralien.* 4th edition, revised by Dr. Reinhard Brauns. 234 pp. and 27 figs. Giessen: J. Ricker'sche Verlags-Buchhandlung. 1898.

The preparation of this fourth edition of Fuchs' *Introduction to the determination of Minerals* has been undertaken with excellent results by Dr. Reinhard Brauns, in succession to the late Prof. Streng.

Only comparatively slight alterations and additions have been made in the first parts of the book, dealing with the "Examination of Minerals with the help of the blowpipe and simple chemical reaction," and in the second part on microchemical reactions which was added by Streng in the preceding edition. The third part, however, consisting of the "Tables for the determination of Minerals by crystal form, physical characters and simple chemical reactions," has suffered a radical change. As indicated in the above heading, the first broad grouping of the minerals was according to the crystalline form. The objections to such a plan are too obvious to mention, and Prof. Brauns has wisely rejected it for an arrangement in which the chief weight is given to characters easily determinable on massive material. As the basis of his classification he has selected hardness in preference to fusibility, which is used for the same purpose in von Kobell's Tables as reproduced in Brush's *Manual of Determinative Mineralogy*. Hardness is not a very precise character of a mineral, but in the hands of students it is probably a more easily determinable and more reliable character than fusibility.

Minerals of approximately the same hardness are then divided into two groups, according as they do or do not possess metallic lustre. Colour and streak are the next marks of distinction, after which come cleavage, form, mode of occurrence, specific gravity and chemical characters.

Tables such as these no doubt fulfil a useful purpose, more especially, perhaps, as a means of instruction to the beginner, although they may not appeal so much to the more advanced student. The gradual tracking down of a mineral, for example, by rigorously following in all its detail such a systematic course of blowpipe and simple chemical tests as that given in the first part of the book, should form an excellent training for the student, until with increase of knowledge he learns to attain the same end by a less circuitous route.

The value of the book to the student has certainly been increased by the changes which Prof. Brauns has made in the present edition.

ABSTRACTS.

Composition of Hamlinite. (S. L. Penfield, *Amer. Journ. Sci.* 1897, IV, 313-316; and *Zeits. Kryst. Min.* 1897, XXVIII, 588). When hamlinite was first described in 1890 (Abstract, IX, 246) only a single specimen, with a few small rhombohedral crystals, was known, so that an analysis was not possible. The mineral has now been found with apatite, herderite and bertrandite on felspar and muscovite in Oxford Co., Maine. The small crystals are rhombohedral ($r\{100\}$ and $f\{\bar{1}11\}$) or prismatic ($m\{2\bar{1}\bar{1}\}$ and $c\{001\}$) in habit, $rr' = 88°41'$. Material could not be collected for analysis by hand-picking, so the specimens were powdered and the hamlinite separated by a heavy fluid; the accompanying apatite was then dissolved in dilute acid. The hamlinite so obtained, of sp. gr. 3·159 – 3·283, appeared to be pure when examined under the microscope. The mean of four partial analyses is—

P_2O_5	Al_2O_3	Fe_2O_3	SrO	BaO	H_2O	F	SiO_2	K_2O	Na_2O	Total (less O for F)
28·92	32·30	0·90	18·43	4·00	12·00	1·93	0·96	0·34	0·40	99·37

Deducting silica, alkalies, &c., as felspar and mica, this agrees closely with the formula $Al_3Sr(OH)_7P_2O_7$ or $[Al(OH)_2]_3(SrOH)P_2O_7$, in which strontium and hydroxyl are partly replaced by barium and fluorine respectively. In its chemical composition, hamlinite holds a unique position amongst minerals, as strontium and barium have never before been observed as essential constituents of a phosphate, and this is the first time a pyrophosphate has been recorded. L. J. S.

Grünlingite, a new mineral from Cumberland. (W. Muthmann and E. Schröder, *Zeits. Kryst. Min.* 1897, XXIX, 140-145). The bismuth telluride from Carrock Fells in Cumberland has usually been called tetradymite (or josëite), although the only analysis (I) which has been made of it (Rammelsberg, 1853) does not agree with the tetradymite formula. The present authors have re-examined the mineral, and find it to have

the composition shown in columns II and III, agreeing with the formula Bi_4S_3Te or Bi(S,Te), for which IV is the calculated composition.

	I.	II.	III.	IV.	V.
S ...	6·43	9·31	9·40	9·10	4·6
Bi ...	84·33	79·31	78·82	78·86	59·0
Te ...	6·73	12·82	12·66	12·04	36·4
	97·49	101·44	100·88	100·00	100·0

The irregular masses examined have a perfect cleavage in one direction. On the cleavage surfaces are cracks intersecting at about 60°, and the thermal conductivity figure is a circle, as observed by G. F. Herbert Smith; the crystal system is therefore probably rhombohedral, as in tetradymite. Sp. gr. 7·321.

In the same paper are given several analyses of Hungarian tetradymite, all of which agree closely with the formula $2Bi_2Te_3,Bi_2S_3=Bi_2Te_2S$, of which V is the calculated percentage composition. L. J. S.

Native Iron in the Coal Measures of Missouri. (E. T. Allen, *Amer. Journ. Sci.* 1897, IV, 99-104). Terrestrial iron has been stated to have been found in eruptive rocks, in river sands with gold and platinum, and in connection with organic matter, but the authenticated occurrences, which are not possibly artificial or meteoric, are very few. In the present paper native iron is described from Cameron, in Clinton Co., Weaubleau, Hickory Co., and Holden, Johnson Co., where it has been met with at depths of from 35 to 51 feet in the sandstone and clays of coal-measure borings. At Cameron the iron occurs in irregular fragments, weighing on an average 0·5 gram, the largest weighing 45·4 grams; it is soft (H = 4), very malleable, and almost silver white in colour. A marked laminated cleavage is present, but no Widmanstätten figures are developed by etching. When first extracted from the matrix the fragments are tarnished, but are free from rust; the sp. gr. varies from 7·43 to 7·88. Analysis shows the material to be almost pure iron (97·10—99·39 per cent. Fe), with small amounts of silica, carbon and phosphorus, but no nickel, cobalt or copper. The depth at which this iron occurs proves it to be of terrestrial origin, and the occurrence in coal-measures is suggestive of reduction. L. J. S.

Crystallised Stannite from Bolivia. (A. W. Stelzner, *Zeits. deutsch. geol. Ges.* 1897, XLIX, pp. 97, 131). A preliminary account of the

late Prof. Stelzner's researches on the silver-tin ores of Bolivia has already been published (Abstract, *Min. Mag.* X, 261; compare this vol. p. 14). In the present important paper (pp. 51-142) full details are given; this paper, with which a good map is issued, is practically a treatise on the minerals of Bolivia. One of the many items of interest is the occurrence of crystallised stannite in the mineral veins of Potosi.

Stannite has previously been considered to be cubic and tetrahedral, but the deltoid-dodecahedral crystals from Peru described by Breithaupt have been shown to be tetrahedrite (p. 75). The cubic crystals now described show the forms $\kappa\{111\}$, $\kappa\{11\bar{1}\}$, $\{110\}$, $\{100\}$, $\kappa\{hkk\}$; the two tetrahedra are equally developed, but differ in lustre. The colour is steel grey, with a yellowish tinge, and the streak is black. Blowpipe analysis of these crystals showed the presence of tin, copper, iron and sulphur, with traces of arsenic, the last, however, probably due to the presence of mispickel. An analysis of the massive mineral (containing some blende and pyrites), by E. Ziessler gave, after deducting 6·96 per cent. of gangue—

Sn.	Cu.	Fe.	Zn.	S.	Total.	Sp. gr.
27·50	29·00	13·75	0·75	29·00	100·00	4·495

The mineral was tested for germanium by Winkler, but with negative results. Heated in the closed tube, it decrepitates and gives off much sulphur; in this it differs from ordinary stannite. Associated with the crystals are pyrites, tetrahedrite, mispickel and quartz. L. J. S.

Stolzite and Raspite from Broken Hill, N.S.W. (C. Hlawatsch, *Ann. k.k. naturh. Hofmus. Wien*, 1897, XII, 33-41; and *Zeits. Kryst. Min.* 1897, XXIX, 130). Transparent, light yellow, red and brownish crystals of stolzite ($PbWO_4$) occur on galena, limonite and psilomelane. Five types of tabular and pyramidal crystals are described; $a : c = 1 : 1{\cdot}15606$.

Raspite, a new dimorphous form of lead tungstate, is found on some of the stolzite specimens as brownish or yellow monoclinic crystals with a strong adamantine lustre. The crystals are flattened parallel to $a(100)$, and elongated in the direction of the axis of symmetry. They are always twinned on $a(100)$; $a : b : c = 1{\cdot}3493 : 1 : 1{\cdot}1112$; $\beta = 72°19'$. Cleavage $a(100)$ perfect. The index of refraction is very high, being about 2·6. Hardness, $2\frac{1}{2} - 3$.

C. W. Marsh (*Trans. Australian Inst. Mining Eng.* IV, 154, 1897) gives several figures of crystals of "stolzite" from Broken Hill, some of which agree exactly with Hlawatsch's description of raspite. Compare also G. W. Card (*Records Geol. Survey N.S.W.* 1897, V, 122). L. J. S.

Calcite with organic colouring matter. (J. Fromme, *Jahresber. Ver. Naturwiss. Braunschweig*, 1897, X, 104-113). The nature of the colouring matter of allochromatic minerals, for example, quartz, calcite, fluorite, &c. is often difficult to determine, and in many cases not known. The author has examined translucent calcite of a chestnut-brown colour from veins in weathered gabbro in Radauthal, near Harzburg, in the Harz. The material is crystalline, and partly in well-developed acute rhombohedra. Iron and manganese are absent. The calcite is completely dissolved in hydrochloric acid, with emission of an asphalte-like smell, frothing, and separation of brown flocks. The filtrate is clear, and of a wine-yellow colour. The brown flocculent material agrees in all its characters with Berzelius' apocrenic acid—an acid related to humic acid, but containing no nitrogen. Another organic acid was isolated from the wine-yellow filtrate. The former is present in the calcite to the extent of 0·2310 per cent., and the latter 0·0135 per cent. Since these substances cannot be extracted from the calcite by reagents, they must exist in combination as the calcium salts.

From a solution of calcium bicarbonate containing an ammonia solution of apocrenic acid, artificial crystals of calcite were obtained. These are acute rhombohedra of a brownish yellow colour exactly like the natural mineral. In the natural formation of the mineral, carbonated rain water takes up ammonia and humic acids from the soil, and this in acting on the lime-felspars of the gabbro produces the coloured calcite.

L. J. S.

Crystalline Form and Chemical Composition of Boulangerite. (H. Sjögren, *Geol. Fören. i Stockholm Förh.* 1897, XIX, 153-167). Boulangerite occurs at Sala in Sweden as acicular and capillary masses embedded in coarsely crystalline calcite. On dissolving the calcite in acid, deeply striated needles are isolated which give good measurements in the prism zone, and in one case from an end face. The orthorhombic parameters agree with those of diaphorite:—

			$a : b : c$
Boulangerite	...	$5PbS.2Sb_2S_3$	0·5528 : 1 : 0·7478
Diaphorite	...	$5(Pb,Ag_2)S.2Sb_2S_3$	0·4919 : 1 : 0·7346

Analysis of this material by R. Mauzelius agrees with the above formula, thus showing the isomorphism of the mineral with diaphorite.

Pb.	Ag.	Zn.	Sb.	S.	Insol.	Total.	Sp. gr.
55·22	trace	0·06	25·54	18·91	0·23	99·96	6·185

The formula always accepted for boulangerite, namely $3PbS.Sb_2S_3$, was first given when the atomic weight of antimony was not exactly known. [Until 1855, Sb=129; Clarke (1897) gives 119·52]. A re-calculation of all the previous analyses shows that the majority agree with the formula $5PbS.2Sb_2S_3$, while none agree exactly with $3PbS.Sb_2S_3$. Embrithite is made a distinct species with the formula $10PbS.3Sb_2S_3$.

L. J. S.

Quartz barytes Rock from Salem, Madras. (T. H. Holland, *Records Geol. Survey, India*, 1897, XXV, 236-242). This rock forms a network of veins, from mere strings to several feet across, in the pyroxenic and other gneisses near Alangayam, in the Tirupatur taluk, Salem district, Madras Presidency. The average sp. gr. is 3·005, from which is calculated 69·2 per cent. of quartz and 30·8 of barytes. The rock, which has the appearance of a pegmatite, is presumably of igneous origin; from the magma, the barytes has crystallised as a rule before the quartz. The low sp. gr. (4·30) of the barytes crystals is accounted for by the presence of 4·01 per cent. of calcium sulphate. Such a mode of occurrence of barytes is unique. L. J. S.

Melting Points of Minerals. (R. Cusack, *Proc. R. Irish Acad.* 1897, V, 399-413). In the present paper a few improvements in Joly's meldometer are described, and the melting points of numerous minerals recorded. As described by Joly (*ibid.* II, 38, 1892; and *Chem. News*, 1892) the instrument consists of a platinum ribbon heated by a current of electricity, which may be gradually increased in strength by reducing the resistance in a rheostat. The temperature of the ribbon is given by its length, as measured by means of a lever and micrometer screw. The substance, of which the melting point is to be determined, is placed in the state of very fine powder on the ribbon, and observed with the aid of a microscope. The instrument is first calibrated with substances of known melting points.

The method gives readings to 2° of temperature, and forms an easy means of determining minerals. The melting points given for specimens of the same mineral species from different localities vary only slightly; a few of the lowest values are quoted below.

Actinolite	1272°	Adularia	1164°	Nephelite	1059°	Rutile	1560°
Hornblende	1187	Albite	1172	Leucite	1298	Brookite	1560
Augite	1187	Microcline	1169	Olivine	1363	Quartz	1425
Diallage	1264	Labradorite	1223	Kyanite	1090	Galena	727
Enstatite	1295	Epidote	954	Andalusite	1209	Blende	1049

L. J. S.

A Microsclerometer for determining Hardness. (T. A. Jaggar, Junr., *Amer. Journ. Sci.* 1897, IV, 399-412, and *Zeits. Kryst. Min.* 1898, XXIX, 262). A summary and classification is given of the various methods which have been employed in the determination of hardness. In the present instrument a cleavage tetrahedron of diamond is made to bore a hole of a certain depth (0·001 mm.) in an artificially prepared crystal section, the rate of rotation and weight on the point being kept constant. The depth of the hole is measured by microscopic focusing on a micrometer scale, and the number of revolutions of the diamond point required to produce this depth is taken as being proportional to the hardness. The relative hardnesses of members of Mohs' scale, as given below, show considerable variations, according to the method of observation.

	Jaggar.	Pfaff (1884).	Rosiwal (1892).	Auerbach.[1]
Gypsum	0·04	12·03	0·34	12
Calcite	0·26	15·3	2·68	80
Fluorite	0·75	37·3	4·70	96
Apatite	1·23	53·5	6·20	206
Orthoclase	25	191	28·7	220
Quartz	40	254	149	267
Topaz	152	459	138	456
Corundum	1000	1000	1000	1000

L. J. S.

Average Specific Gravity of Meteorites. (O. C. Farrington, *Journ. of Geology*, 1897, V, 126-130). From the weights and specific gravities of 142 meteorites, of which the fall has been recorded during the last 100 years, the average specific gravity of meteoric matter is deduced as 3·69.

L. J. S.

Spectrographic Analysis of Meteorites. (W. N. Hartley and Hugh Ramage, *Sci. Proc. Roy. Dublin Soc.* 1898, VIII. 703-710). By spectrographic methods the authors have previously detected the presence of the rare element gallium in several iron ores and bauxites. In meteoric irons, siderolites and stones of 13 falls, lines of the following elements have been identified: calcium, iron, nickel, cobalt, chromium, gallium, lead, manganese, silver, copper, sodium, potassium, rubidium and mag-

[1] *Ann. Phys. Chem.* LVIII, 357, 1896.

nesium. Copper, lead and silver are common constituents. Gallium is present in all the irons, but not in all the stones, examined. L. J. S.

On Leucite and Analcite and their mutual relations. (C. Klein, *Sitzungsber. k. preuss. Ak. Berlin*, 1897, XVI, 290-354). This paper is divided into three sections. I. is historical, and consists of an exhaustive discussion of previous work. II. is subdivided into two parts: the author in (*a*) describes the apparatus used for heating the crystals, and in (*b*) gives the results of his own observations. III. gives an epitome of the results, and the conclusions to be deduced. The symmetry of leucite is rhombic, but very nearly tetragonal, the bi-refringence being positive about the first mean line. The author thinks that if leucite changes its molecular-structure at 560°, the new arrangement varies with the three axes, depending on the faces and symmetry of the prevailing form. Analcite, on the other hand, is monoclinic, but very nearly tetragonal, the character of the bi-refringence being negative about the first mean line. In places this mineral is isotropic. The optical anomalies of leucite are caused by the crystals being formed at a high temperature, and the molecular structure changing on cooling. If analcite be heated in a damp atmosphere to about 200°-250° it becomes isotropic, but if to 500° the bi-refringence becomes stronger. The optical anomalies seem to be due to loss of water and changes in temperature and pressure.

G. F. H. S.

The Optical Anomalies of Analcite from Montecatini. (G. D'Achiardi, *Proc. Verb. della Soc. Toscana di Sc. Nat.* 1897, X, 267-276). The crystals have the form {211} well developed, sometimes associated with small faces of the cube. Sections parallel to (100), (111) and (211), cut both in the middle and near the surface of the crystals, were examined under the microscope. The observations are described, and are in agreement with those of Ben Saude, Brauns and Klein, showing that each crystal is composed of 24 monoclinic individuals having for base as many faces of the icositetrahedron. Sections cut near the middle of the crystals always showed an isotropic part in the centre. From this, and also since analcite on heating to 200°-250° in a damp atmosphere becomes isotropic, the author thinks the optical anomalies of this mineral are due to loss of water, probably the last phase of crystallisation. G. F. H. S.

Langbeinite, the first example of cubic tetartohedrism in minerals. (O. Luedecke, *Zeits. Kryst. Min.* 1898, XXIX, 255-261). Borings were

made at Huy, near Anderbeck, for potassium salts. Dr. Zuckswerdt published in 1891 an analysis of salt from a depth of 230 metres, and showed that the formula is $K_2Mg_2S_3O_{12}$. This analysis was made on material mixed up with as much as 47·85 per cent. of NaCl, but later analyses on carefully selected material agree closely with the formula. The author is aware of only three crystals existing. He describes one which clearly shows tetartohedral symmetry, and gives the crystallographic details. The forms present are {100}, {111}, {1$\bar{1}$1}, {2$\bar{1}$1}, {2$\bar{2}$1}, {310}, {210} and perhaps {920}, and finally {110}. In this class of symmetry there are four trigonal axes of symmetry which are polar in character. This property was shown by etching; the negative tetrahedron faces showed worm-shaped figures, whilst the positive faces were unaffected. The refractive indices were found to be $n_{Li} = 1{\cdot}5281$, $n_{Na} = 1{\cdot}5329$, $n_{Tl} = 1{\cdot}5343$. Sp. gr. is 2·827; fracture conchoidal; lustre vitreous. The mineral rapidly absorbs moisture from the air, and becomes opaque. G. F. H. S.

A Quartz double-plate. (F. Stöber, *Zeits. Kryst. Min.*, 1898, XXIX, 22-24). The double-plate consists of two quartz sections cut parallel to the axis, which touch in a direction making an angle of 45° with the axes, so that these are at right angles. The most convenient thickness is that—about ·064 mm. - which gives between crossed nicols the violet of the second order. The plate, after being protected by cover-glasses, is placed near the cross wires in the eye-piece, so that the line of separation coincides with a wire. If the analysing nicol be above the eye-piece, this plate can be used for the following determinations:—

1. Weak bi-refringence.
2. Stauroscopic measurements.
3. Character of the bi-refringence in thin mineral sections if the position of the axes in the two halves of the plate is known.
4. The planes of symmetry of the optical ellipsoid.
5. The position of the optic axes in parallel polarised light.

G. F. H. S.

A simple Theodolite-Goniometer, and its employment in stauroscopic determinations. (F. Stöber, *Zeits. Kryst. Min.* 1898, XXIX, 25-32). The author shows how such an instrument can be easily constructed by the addition of a vertical double ring to an ordinary Fuess goniometer. The double ring is mounted on a cylindrical axis, which takes the place of the axis attached to the original crystal holder. The inner ring,

which is graduated, can turn inside the outer, to which is attached a vernier reading to minutes, about a horizontal axis. The new crystal holder is clamped to the inner ring, and projects in a radial direction; it is capable of extension in the same direction, and the crystal may thus be accurately centred. The necessary adjustments are described. The instrument is used in the ordinary way, with the telescope and collimator at right angles for about 300° of the horizontal scale. For the remaining 60° the ring will be in the way of the collimator or the telescope. By moving the telescope through 40° this difficulty may be overcome. Of course half this value must be added to or subtracted from the azimuthal reading, as the case may be.

The instrument can be conveniently used for stauroscopic determinations by removing the crystal holder and fitting a glass plate into the inside of the ring. To this the crystal section is affixed by means of a pair of springs. Nicol prisms are fitted to the telescope and collimator on the sides next to the crystal section. G. F. H. S.

Some Minerals in the neighbourhood of Schlaining. (A. Schmidt, *Math. és term. tud. Ertesitő*, Buda-Pesth, 1897, 15; and *Zeits. Kryst. Min.* 1898, XXIX, 193-212). After a discussion of former work on the subject, the author gives a detailed account of his own studies. Six crystals of stibnite from Bergwerk (Bánya) are figured and described, and the measurements given. The following new forms were found: {034}, {40.19.10}, {10.9.15}, {563} and {12.19.3}. Crystals of the same mineral from Schlaining are similar in habit, having {343} prominent, but, being covered with a crust, could not be accurately measured. Some small bright crystals of sulphur were found on the specimens. Four such are described, and the measurements given. They appear to be the result of the decomposition of the stibnite. The other minerals met with are gypsum, calcite in small crystals (showing the form {110}), barytes in thin tablets (with the forms {001}, {110}, and very small {104}, {102}), and a crust of cinnabar. G. F. H. S.

Note on Tuscan Minerals. (G. D'Achiardi, *Proc. Verb. Soc. Tos. di Sc. Nat.* 1897, X, 210-4.) 1. Epsomite from Jano. Some crystals are fairly large, and stand alone; others are embedded in a crystalline crust of chalk. Hemihedrism is well shown by the different developments of faces of the same forms. The axial ratios agree with those found by Miller. The optical characters agree with those determined by Des Cloizeaux. Transparent crystals often show air bubbles with liquid

inclusions, and the faces are corroded. The mineral is probably due to water rich in sulphur attacking miemite, resulting in chalk and epsomite.

2. Cerussite from Valdaspra. Associated with the aurichalcite from this district are numerous small crystals which on microscopic and chemical investigation were found to be cerussite with forms probably {110}, {100}, {010}, {111}, and {011}.

3. A specimen of pyrites from Carrara shows two cubes in juxtaposition twinned about (320). G. F. H. S.

On the reproduction of the diamond. (Q. Majorana, *Rend. della R. Acc. dei Lincei*, 1897, VI, 141.) Amorphous carbon has a density less than 2, graphite has a density of 2·5 and diamond of 3·5. To produce diamonds from amorphous carbon a high temperature and a great pressure is required. Pieces of carbon of the kind used for the arc light—sugar is preferable, but would not be compact enough—were heated between the poles of an electric arc. A current of 100 volts and 25 ampères was used. The carbon is fixed to a small steel piston rod 1 cm. in diameter, which fits into a cavity in a steel block. On the other side the rod joins a larger piston, which fits a cylinder hermetically sealed at one end. The apparatus is calculated to withstand a pressure of about 5,000 atmospheres. Gunpowder is placed in the cylinder, and exploded electrically. The pressure thus excited is exerted on the heated carbon by means of the piston. The resulting mass, which has a density of 2·28, is reduced by Berthelot's method as modified by Moissan, until finally some small particles are evolved; these are usually opaque, but sometimes transparent. Both kinds have the density, hardness and crystalline structure of diamond, and are not affected by acids. G. F. H. S.

CONTENTS OF No. 54.

PAGE

Augelite from a New Locality in Bolivia. By L. J. Spencer, M.A., F.G.S., Assistant in the Mineral Department of the British Museum 1

Stanniferous Argyrodite from Bolivia: The Identity of the so-called "Crystallised Brongniardite" with Argyrodite-Canfieldite. By G. T. Prior, M.A., F.G.S., and L. J. Spencer, M.A., F.G.S., Assistants in the Mineral Department of the British Museum 5

Atacamite from Sierra Gorda, Chili. By G. F. Herbert Smith, B.A., Assistant in the Mineral Department of the British Museum 15

On Sphærostilbite. By G. T. Prior, M.A., F.G.S., Assistant in the Mineral Department of the British Museum 26

On Senaite, a new Mineral belonging to the Ilmenite Group from Brazil. By Dr. E. Hussak, of the Geological Survey of S. Paulo; and G. T. Prior, M.A., F.G.S., Assistant in the Mineral Department of the British Museum 30

Note on peculiar Quartz-Pseudomorphs found at the Owera Mine, Opitonui, North Island, New Zealand. By Prof. G. H. F. Ulrich, F.G.S. [Communicated by Prof. Judd, C.B., F.R.S.] 33

Notes and Comments 35

Obituaries. Alfred Olivier Des Cloizeaux..... 37

Emeritus-Professor M. Forster Heddle, M.D., F.R.S.E. 38

Albrecht Schrauf 42

Reviews 43

Abstracts 45

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